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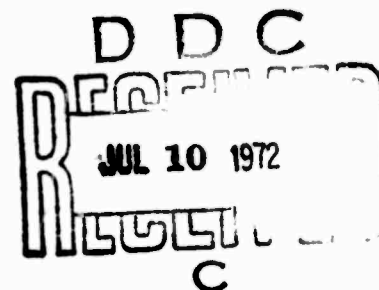
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ARMY PRELIMINARY EVALUATION

PROTOTYPE HUGHES MODEL 369C (OH-6C) HELICOPTER

FINAL REPORT



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FEBRUARY 1972

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US ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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ABSTRACT

The Army Preliminary Evaluation (APE) of the Hughes Tool Company -- Aircraft Division (HTC-AD) prototype Model 369C (OH-6C) helicopter was conducted at the Hughes facility in Culver City, California. A total of 34.6 productive flight hours were accumulated during the period 26 August to 22 September 1971. Engineering flight tests were conducted to evaluate the performance, handling qualities, and contractor-proposed flight envelope and to provide data for future use in the evaluation of the HTC-AD New Initiatives -- Aerial Scout Program proposal. The data indicate that, in comparison with the OH-6A, the Hughes Model 369C can hover out of ground effect on a 35°C day at 4000 feet with a 207-pound increase in payload. The Model 369C can achieve a maximum level flight airspeed of 141 knots calibrated airspeed (KCAS) with a 660-pound payload -- an increase of 14 percent over the 124-KCAS never-exceed velocity of the OH-6A. One deficiency, inadequate longitudinal control during sideward and rearward flight at a forward center-of-gravity (cg) loading, and 12 shortcomings were observed in the handling qualities evaluation. In the OH-6A speed range, the static and dynamic stability and controllability of the Model 369C are generally unchanged. At the airspeeds that exceeded the envelope of the OH-6A, handling qualities were degraded, and five shortcomings were observed. These shortcomings were neutral maneuvering stability, neutral static longitudinal stability, excessive longitudinal control response and sensitivity, excessive roll response following a simulated directional gust disturbance, and excessively rapid buildup of normal acceleration following a simulated longitudinal gust disturbance. If procurement of the helicopter is planned, the cited deficiency should be corrected prior to any airworthiness release for flight at a forward cg loading by operational pilots. The shortcomings should be corrected prior to production. Additional testing should be conducted to determine a safe operational cg envelope, to develop a height-velocity curve, and to evaluate the effects of altitude, weight, and cg variations.



FOREWORD

Throughout the preliminary evaluation, instrumentation calibration, photography, and some technical assistance were provided by the airframe manufacturer, Hughes Tool Company - Aircraft Division, Culver City, California, and more specifically by Project Engineer John Bardell. Flight support was provided by CWO George Karcher of the US Army Hughes Plant Activity, through permission of the Commanding Officer, LTC D. J. Amaral.

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INTRODUCTION

BACKGROUND

1. The Hughes Tool Company - Aircraft Division (HTC-AD) developed a derivative of the OH-6A helicopter intended to improve performance. Designated by Hughes as the Model 369C, the helicopter has been unofficially referred to as the OH-6C. The Model 369C represents the basic airframe for the HTC-AD proposal for the New Initiatives - Aerial Scout Program. The US Army Aviation Systems Command (AVSCOM) directed the US Army Aviation Systems Test Activity (USAASTA) to conduct an Army Preliminary Evaluation (APE) of the prototype Model 369C (ref 1, app A).

TEST OBJECTIVES

2. The primary objective of this test was to evaluate the performance and handling qualities of the Model 369C for future use in the evaluation of the New Initiatives - Aerial Scout Program proposal. A second objective was to verify that the recommended flight envelope was safe for subsequent test programs and demonstration flights.

DESCRIPTION

3. The Model 369C helicopter flown during the APE was a modified OH-6A, serial number (S/N) 65-12951, manufactured and modified by the Hughes Tool Company - Aircraft Division. A detailed description of the OH-6A is found in reference 2, appendix A. A general aircraft and component description of the Model 369C is presented in appendix B, with photographs 1 through 3 illustrating the major configuration changes. The Model 369C incorporates the following major changes to the OH-6A.

- a. Five-bladed main rotor.
- b. Four-bladed tail rotor.
- c. "T" tail.
- d. Main transmission uprated to a maximum of 355 shaft horsepower (shp).
- e. New tail rotor gearbox.
- f. Strengthened canopy and tail boom.
- g. Allison 250-C20 engine rated at 400 shp, sea-level, standard-day conditions (with CECO fuel control).

SCOPE OF TEST

4. Performance and handling qualities were evaluated throughout the flight envelope and were compared against estimated performance presented in HTC-AD report number 369-X-8032A (ref 3, app A), performance and handling qualities of the OH-6A (ref 4), and military specification MIL-H-8501A (ref 5). Particular attention was paid to those capabilities outside the OH-6A flight envelope (gross weights of 2700 to 3150 pounds and airspeeds of 124 to 150 knots calibrated airspeed (KCAS)). The test conditions are presented in tables 1 and 2, appendix C.

5. Operating procedures and limitations were in accordance with the OH-6A operator's manual (ref 2, app A), except as modified by the AVSCOM safety-of-flight release (app D) and operating procedures provided by HTC-AD. A total of 40 flights were conducted for 34.6 productive test hours during the period 26 August to 22 September 1971 at the Hughes facility at Culver City, California. A majority of the tests were conducted under nonturbulent atmospheric conditions to preclude uncontrolled disturbances from influencing the helicopter characteristics. A limited number of flights were accomplished in turbulent air conditions in order to evaluate the stability and control of the helicopter under representative operating conditions.

METHODS OF TEST

6. Test methods used are described in detail in references 6 and 7, appendix A, and are described briefly in the Results and Discussion section of this report. A Handling Qualities Rating Scale (HQRS) was used to augment pilot comments relative to handling qualities (app E).

7. Weight and balance was conducted by HTC-AD. Because of erroneous weight and balance determination provided by the contractor, some test data were collected at a center of gravity (cg) up to 0.2 inch outside of the operational envelope due to fuel burn-off. This error was discovered after completion of flying. Considering the allowable cg range of the helicopter (7 inches), the effect of 0.2 inch is considered to be negligible.

8. The test helicopter was equipped with sensitive calibrated instruments to gather the data presented in this report. A list of the test instrumentation is included in appendix F.

CHRONOLOGY

9. The chronology of the Hughes Model 369C APE is as follows:

Test directive received by telephone	20	August	1971
Test aircraft received	24	August	1971
Tests started	26	August	1971
Test directive received	7	September	1971
Tests completed	22	September	1971
Contractor debriefing	30	September	1971

RESULTS AND DISCUSSION

GENERAL

10. Engineering flight tests were conducted to evaluate the performance, handling qualities, and the contractor-proposed flight envelope of the Hughes Model 369C helicopter. Compared to the OH-6A, the Model 369C had increased hover ceiling and/or payload capability as well as a higher maximum speed. One deficiency, inadequate longitudinal control during sideward and rearward flight at a forward cg loading, and 12 shortcomings were observed in the handling qualities evaluation. In the OH-6A speed range, the static and dynamic stability and controllability of the Model 369C are generally unchanged. Handling qualities are degraded at airspeeds that exceed the envelope of the OH-6A. If procurement of the helicopter is planned, the cited deficiency should be corrected prior to any airworthiness release for flight at a forward cg loading by operational pilots. The shortcomings should be corrected prior to production. Additional testing should be conducted to determine a safe operational cg envelope, to develop a height-velocity (H-V) curve, and to evaluate the effects of altitude, weight, and cg variation.

PERFORMANCE

General

11. Tests were conducted to determine hover, level flight, and autorotational descent performance characteristics of the Model 369C helicopter. Hover results indicate that, in comparison with the OH-6A, the Model 369C, using takeoff power, can hover out of ground effect (OGE) on a hot (35°C) day at 4000 feet with a 207-pound increase in payload. Level flight performance was also improved. The Model 369C has a maximum level flight airspeed of 141 KCAS with a 660-pound payload - an increase of 14 percent over the 124-KCAS never-exceed velocity (VNE) of the OH-6A. Autorotational descent characteristics were satisfactory, although the rate of descent of the Model 369C was greater than the OH-6A.

Hover

12. Hover performance tests were conducted at skid heights of 4 feet in ground effect (IGE) and 60 feet OGE under the conditions listed in table 1, appendix C. Skid height was measured from the bottom center of the left skid. The tethered hover method, employing a calibrated load cell in series with a cable attached to the helicopter cargo hook and a ground tie-down, was used to determine main rotor thrust. Data were obtained at various power settings up to the 355 shp transmission (XMSN) limit at rotor speeds of 505 and 510 rpm. Specification fuel flow and installed power available for the Allison 250-C20 engine are shown in

figures 1 through 4, appendix G, and were used to determine aircraft performance. Nondimensional hover performance data are presented in figure 5. Both IGE and OGE hover performance were derived from figure 5. Hover ceiling plots are presented in figures 6 and 7.

13. Hover capability for both a standard day (15°C at sea level) and a hot day (35°C at all altitudes) were determined from figures 6 and 7, appendix G. The data indicate that at the maximum design gross weight of 3150 pounds, the Model 369C helicopter can hover IGE at 6700 feet on a standard day and 1500 feet on a hot day. At 3150 pounds, the standard-day OGE hover ceiling is 2350 feet, while on a hot day the gross weight must be reduced to 3040 pounds to hover OGE. Although testing was not conducted at altitudes higher than the test density altitude of 600 feet, it appears that the contractor hover performance predictions, as presented in reference 3, appendix A, were all met. A comparison of the hover capability of the Model 369C and the OH-6A is shown in table 1. The Model 369C can hover OGE on a hot day at 4000 feet with a 207-pound increase in payload. This increased capability of the Model 369C helicopter enhances its operational value. Further testing should be conducted to determine high-altitude performance.

Table 1. Hovering Capability Comparison.

Pressure Altitude: 4000 feet
Outside Air Temperature: 35°C

Characteristic	Hughes Model 369C	OH-6A	Difference
Basic weight ¹ (lb)	1344	1146	198
Rotor speed ² (rpm)	510	483	27
Operating weight ³ (lb)	1950	1752	198
IGE ⁴ hover performance:			
Maximum hover weight (lb)	2850	2395	455
Payload (lb)	650	443	207
OGE hover performance:			
Maximum hover weight (lb)	2600	2105	405
Payload (lb)	650	443	207

¹Includes helicopter airframe and engine plus full hydraulic fluid and trapped fuel.

²Power turbine speed (N₂) equals 103 percent.

³Includes basic weight plus engine oil, full fuel, and a 200-pound pilot.

⁴Four-foot skid height.

Level Flight

14. Level flight performance tests were conducted to determine power required as a function of airspeed under the conditions listed in table 1, appendix C. The results of the individual tests are presented in figures 8 through 14, appendix G. Data were obtained in stabilized level flight at airspeed increments of 10 knots from 30 knots indicated airspeed (KIAS) to the maximum level flight airspeed (V_H) while flying at the desired ratio of gross weight to density altitude and at a constant 510 rpm. A comparison of nondimensional data of the OH-6A and the Model 369C indicates that for the Model 369C larger power coefficients (C_p 's) are required at low thrust coefficients (C_T 's) while lower C_p 's result at higher C_T 's. It was concluded that the Model 369C with the larger engine becomes more efficient in terms of power required as weight and airspeed are increased. A comparison of the level flight performance capability of the OH-6A and the Model 369C at an equal payload for each helicopter is shown in figure A. The OH-6A has a V_{NE} of 124 KCAS, which is a structural limitation. The Model 369C is limited by power available and not by structural considerations. Using takeoff power, the Model 369C has a level flight airspeed of 141 KCAS – an increase of 14 percent over the 124-KCAS V_{NE} of the OH-6A. This increased airspeed of the Model 369C enhances its operational value. Figure A illustrates a V_H of 141 knots true airspeed (KTAS) but a maximum cruise airspeed of only 126 KTAS due to the maximum-continuous transmission limit of 278 shp. Removing the maximum-continuous transmission limit will enable the helicopter to achieve substantially higher airspeeds in level flight at sea level.

15. Range performance of the Model 369C helicopter was calculated from the level flight performance data for sea-level, standard-day conditions presented in figure 15, appendix G. An average cruise airspeed of 121.5 KTAS was employed, and the range of 238 nautical air miles was computed as follows:

a. Takeoff conditions:

Basic weight (Model 369C)	1344 pounds
Oil, engine	6 pounds
Fuel	400 pounds
Pilot	200 pounds
Payload	1200 pounds
Total:	3150 pounds

b. Range calculations:

Engine start gross weight	3150 pounds
Warm-up (2 minutes)	2 pounds
Cruise fuel	358 pounds
Landing gross weight	2790 pounds
Ten-percent fuel reserve	40 pounds

c. Range = average nautical air miles per pound of fuel x cruise fuel

$$= \frac{0.654 + 0.673}{2} \times 358 = 238 \text{ nautical air miles}$$

DENSITY ALTITUDE = SEA LEVEL

PAYLOAD = 660 LB

CG LOCATION = MID

POWER TURBINE SPEED = 103 PERCENT

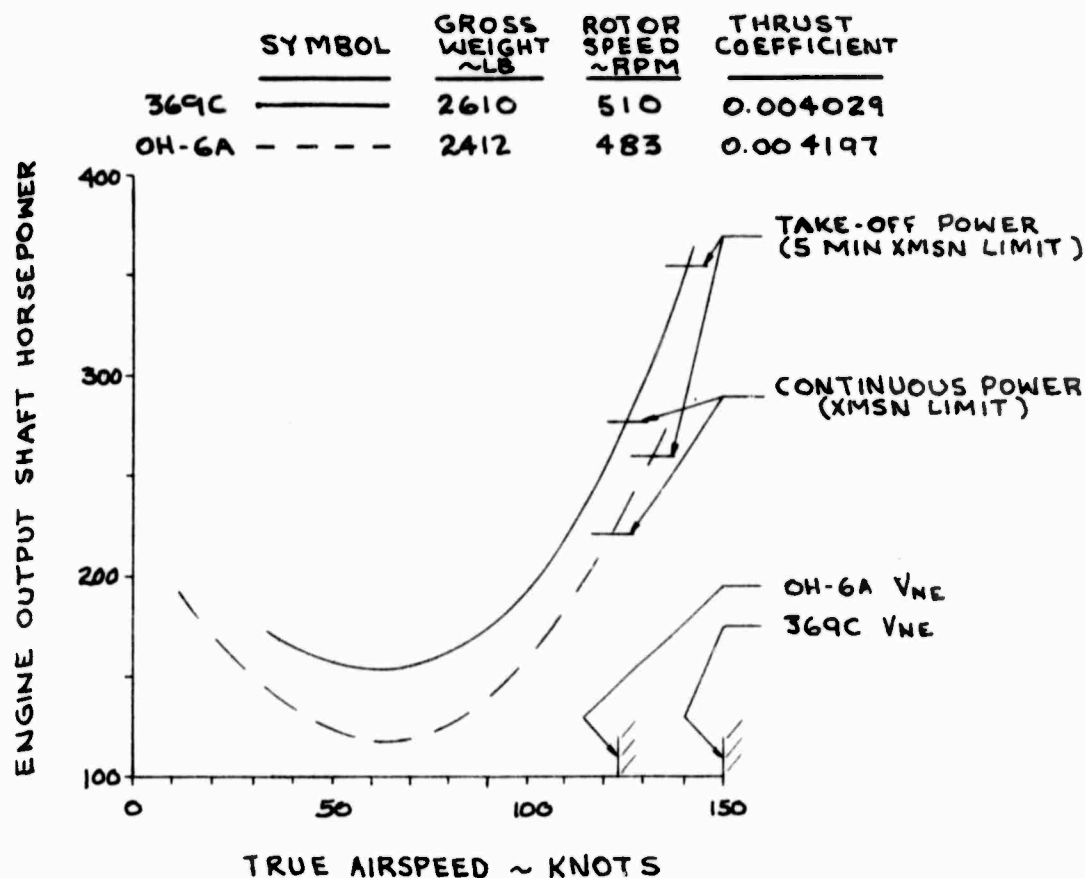


Figure A. Level Flight Power Required Comparison at Equal Payload.

Autorotational Descent

16. Autorotational descent performance tests were conducted under the conditions listed in table 1, appendix C, and the test results are presented in figures 16 and 17, appendix G. Autorotational descent performance was determined by timing stabilized autorotational descent through a 1000-foot altitude band. Under

test conditions, the airspeed for a minimum rate of descent of 1720 feet per minute (ft/min) was 60 KCAS at a rotor speed of 510 rpm. The airspeed for maximum glide distance was extrapolated to be 102 KCAS with a rate of descent of 2200 ft/min. Approximately 0.79 nautical air miles could be traversed for every 1000 feet of descent. In comparison with the OH-6A at its alternate mission gross weight of 2400 pounds, the Model 369C at 3050 pounds exhibited an increase in rate of descent and a decrease in maximum glide distance. At an airspeed of 60 KCAS, tests were conducted at various rotor speeds in the autorotational range of 462 to 526. The test results in figure 17 show that the low rotor rpm (462) produced a rate of descent of 1590 ft/min, while the high rotor rpm (526) had a rate of descent of 1810 ft/min. Within the scope of this test, the autorotational descent performance of the Model 369 helicopter is satisfactory. Further testing should be conducted to evaluate autorotational performance during high density altitude operations.

STABILITY AND CONTROL

General

17. Stability and control tests were conducted at the conditions listed in table 2, appendix C. One deficiency and 12 shortcomings were observed. The deficiency and 7 of the shortcomings occurred within the speed range of the OH-6A. The remaining shortcomings occurred within the expanded airspeed envelope of the Model 369C. The deficiency was inadequate longitudinal control to counteract the effects of longitudinal disturbance during left sideward and rearward flight at a forward cg. The most serious shortcomings of the Model 369C were in the expanded flight envelope and represented a degradation from the OH-6A handling qualities. These shortcomings were neutral maneuvering stability, neutral static longitudinal stability, excessive longitudinal control response and sensitivity, excessive longitudinal control response and sensitivity, excessive roll response following a simulated directional gust disturbance, and excessively rapid buildup of normal acceleration following a simulated longitudinal gust disturbance.

Trim Control Position Characteristics

18. The trim control position characteristics of the Model 369C helicopter were evaluated under the conditions listed in table 2, appendix C, and were determined by recording the control positions at various coordinated flight conditions. Test results are presented in figures 18 and 19, appendix G. During both level flight and maximum power climbs, consistently forward longitudinal control trim positions were required at increased forward speeds. Trim control position variations with airspeed were essentially linear, and adequate control margins were available for all controls. During climbs at maximum power, a noticeable increase in left pedal was observed but was not considered excessive. Within the scope of this test, the trim control position characteristics of the Model 369C helicopter are satisfactory.

Sideward and Rearward Flight

19. Sideward and rearward flight were evaluated under the conditions listed in table 2, appendix C. The helicopter was stabilized at a hover and at 5-knot increments up to the sideward and rearward airspeed limits. A ground pace vehicle with a calibrated fifth wheel was used as a speed and position reference during the test. With the aircraft maintained at a skid height of approximately 5 feet, control positions were recorded at each stabilized point. Test results are presented in figures 20 and 21, appendix G.

20. During sideward flight, increasing lateral cyclic control was required in the direction of flight up to 15 knots in either direction. At higher speeds, no further lateral control was required. Increasing left directional control in right sideward flight and right directional control in left sideward flight were required throughout the speed range. Forward longitudinal control was required in right sideward flight, and aft longitudinal control was required in left sideward flight to approximately 15 knots in either direction. At higher speeds, essentially no additional longitudinal control was required. The task of stabilizing in left sideward flight in the 5- to 20-knot band was very difficult because the motion of the helicopter was characterized by random yaw oscillations which required large and rapid movements of the directional control (HQRS 4). This directional instability in left sideward flight is a shortcoming, correction of which is desired if the helicopter is procured.

21. Control margins were satisfactory for lateral and directional controls but were less than 10 percent for aft longitudinal control in left lateral flight above 10 knots at the forward cg. The position of the longitudinal control during this flight condition was uncomfortable to the pilot, and the control available to counteract a longitudinal disturbance was considered insufficient to meet the requirements of paragraph 3.2.1 of MIL-H-8501A. The inadequate longitudinal control margin during left sideward flight at a forward cg loading may result in loss of control in gusty wind conditions and is a deficiency. If the helicopter is procured, correction of this deficiency is mandatory prior to release of the Model 369C for flight at a forward cg.

22. Considerable difficulty was encountered while attempting to stabilize between hover and 15 knots rearward. While in this airspeed band, random yaw oscillations occurred, requiring large and rapid movements of the pedals to prevent loss of directional control (HQRS 4). From 15 knots rearward to the limit, the aircraft was much easier to stabilize (HQRS 2). The directional instability in rearward flight is a shortcoming, correction of which is desirable if the helicopter is procured.

23. Control margins were satisfactory for both lateral and directional controls but were less than 10 percent for aft longitudinal control in rearward flight above 13 knots. The remaining control available to counteract a longitudinal disturbance was considered insufficient to meet the requirement of paragraph 3.2.1 of MIL-H-8501A. The inadequate longitudinal control margin during rearward flight at a forward cg loading may result in loss of control in gusty wind conditions and is a deficiency. If the helicopter is procured, correction of this deficiency

is mandatory prior to release of the Model 369C for flight at a forward cg. Further testing in sideward and rearward flight conditions at different altitudes should be conducted to determine a safe operational cg envelope.

Critical Wind Azimuth Determination

24. The critical wind azimuth of the Model 369C helicopter was determined under the conditions listed in table 2, appendix C. Critical wind azimuth is defined as that relative wind direction which results in the least remaining control margin while attempting to hover over a spot on the ground. The helicopter was hovered at an approximate 3-foot skid height in a known wind condition (10 to 16 knots) and rotated through a 360-degree turn. Control positions were recorded at stabilized increments of turn relative to the wind azimuth. Test results are presented in figure 22, appendix G. Adequate control margin was available in all axes for conditions tested. The critical control was directional and occurred during pedal excursions required to stabilize with a left quartering wind between 172 and 285 degrees clockwise from the nose of the aircraft.

Hovering Flight Characteristics

25. Hovering flight characteristics of the Model 369C helicopter were evaluated throughout the test program. Takeoffs to a hover at approximately 3200 pounds with both a forward and aft cg were accomplished with adequate control margin for all controls. Power management was satisfactory; however, the fuel control system of the 400-horsepower Allison engine overcompensates for rotor droop, resulting in an increase of approximately 1.5-percent power turbine speed (N_2) as the helicopter is brought to a hover. This characteristic was not objectionable. However, if this engine/fuel control combination is bought for Army use, the following "NOTE" should be included in the appropriate operator's manual:

NOTE

The fuel control system overcompensates for rotor droop as collective pitch is increased and may result in overspeeding the engine.

26. In a hover, approximately 25 pounds of left pedal force was required. This excessive pedal force was objectionable to the pilot (HQRS 4) and limits the operational suitability of the helicopter. The excessive left pedal force of the Model 369C during hover failed to meet the requirements of paragraph 3.3.12 of MIL-H-8501A by 10 pounds, or 67 percent, and is a shortcoming, correction of which is desired if the helicopter is procured.

27. During hover, lateral control vibrations at 8.5 and 42.5 hertz corresponding to one per rotor revolution (1/rev) and 5/rev were observed. These vibrations were very objectionable, added to the workload of the pilot, and contributed to pilot-induced oscillations (HQRS 4). After testing was complete, the contractor installed different main rotor dampers, and two test flights were conducted at light

and heavy gross weights. Lateral control vibrations were reduced to a satisfactory level. The new main rotor dampers were identified as HTC-AD part number 369ASK1933. These dampers should be installed on the Model 369C helicopter if considered for procurement.

28. In a hover, the Model 369C helicopter at maximum gross weight is less affected by wind than the standard OH-6A. This improvement in hovering stability was noteworthy; however, in winds greater than 5 knots or under gusty wind conditions, pilot workload required to perform precision hovering tasks was still excessive. During critical wind azimuth determination, pedal excursions up to 2.2 inches were measured (fig. 22, app G). In addition to pedal excursions, collective and cyclic control were continually moving in a maximum performance effort to stabilize (HQRS 5). The excessive pilot workload required to perform precision hovering tasks is a shortcoming, correction of which is desirable if the helicopter is procured.

Static Longitudinal Collective-Fixed Stability

29. Static longitudinal collective-fixed stability tests were conducted under the conditions listed in table 2, appendix C. Static longitudinal stability was determined by initially stabilizing at selected trim airspeeds, and recording data to determine control positions. Airspeed was then increased and decreased to stabilized points while keeping the collective control unchanged and control positions were again recorded. These data are presented in figure 23, appendix G.

30. As evidenced by the variation about trim of the longitudinal control position, the Model 369C was statically stable (increasing longitudinal control with increasing airspeed) at the lower of the three trim airspeeds (54 KCAS), but became increasingly less stable as airspeed increased. Pilot workload increased while attempting to maintain a desired airspeed approaching V_H (HQRS 5). In contrast, the OH-6A data in reference 4, appendix A, revealed a slightly stable trend at a trim airspeed of 54 KCAS and became more stable as airspeed was increased. A comparison of the static longitudinal stability characteristics of the two helicopters is presented in figure B. The flight conditions for this comparison were similar, except for the higher gross weight of the Model 369C. The OH-6A data in reference 4, appendix A, indicate that the effects of increased altitude and gross weight were negligible. The neutral static longitudinal stability of the Model 369C in the airspeed band of 130 KCAS to V_H failed to meet the requirement of paragraph 3.2.10 of MIL-H-8501A and is a shortcoming, correction of which is desired if the helicopter is procured. Additional testing should be accomplished to determine the effect of altitude, weight, and cg change on the static longitudinal stability of the Model 369C.

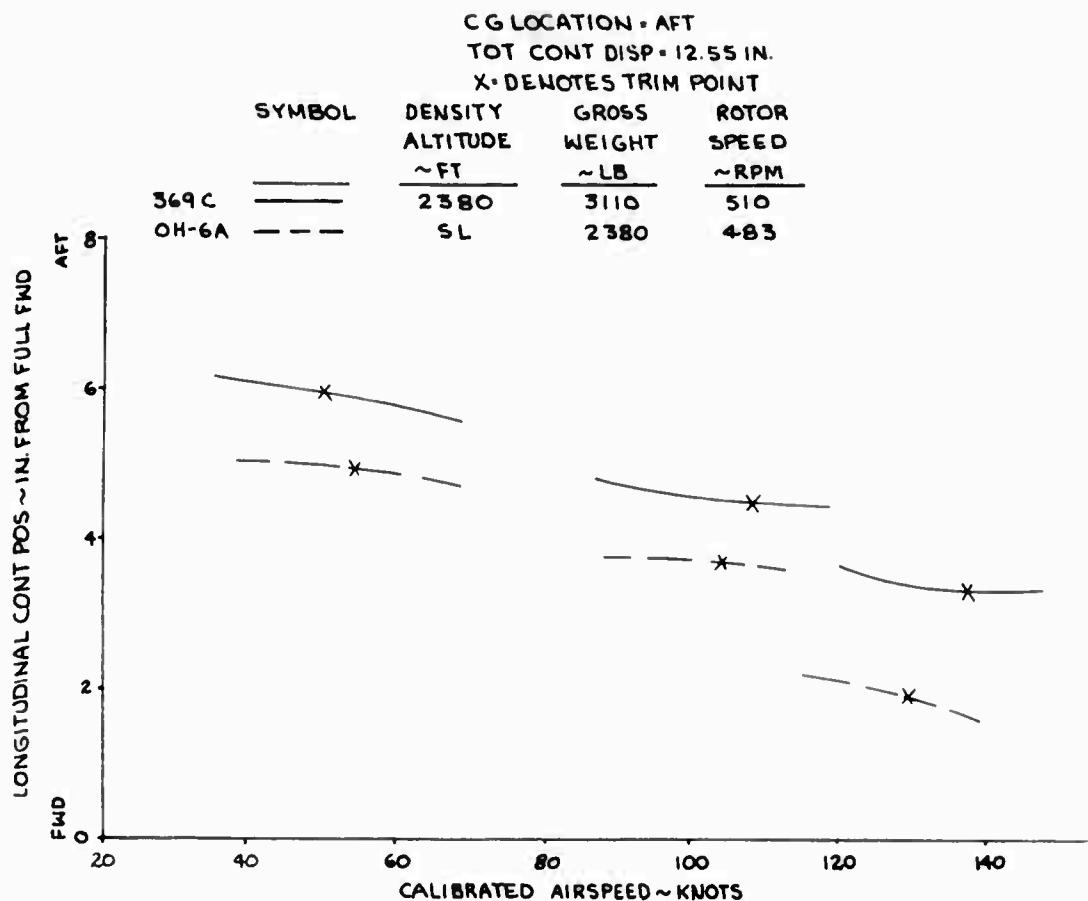


Figure B. Static Longitudinal Collective-Fixed Stability Comparison.

Static Lateral-Directional Stability

31. The static lateral-directional stability tests of the Model 369C were conducted under the conditions listed in table 2, appendix C. The test helicopter was first stabilized at the trim airspeeds, and then sideslip angle was increased in increments from zero to the envelope limits in both directions while maintaining a straight flight path over the ground. At each increment of sideslip, control positions and

sideslip angle were recorded while holding collective fixed and maintaining trim airspeed. The test results are presented in figures 22 through 26, appendix G.

32. The Model 369C helicopter exhibited positive static lateral-directional stability, in that left directional and right lateral control displacements were required for right sideslip. Increasing stability was noted as trim airspeed increased. One flight was conducted at an average gross weight of 2440 pounds for comparison with OH-6A data (ref 4, app A). The static lateral-directional stability characteristics of the two helicopters appear to be essentially the same. Within the scope of this test, the static lateral-directional stability of the Model 369C helicopter is satisfactory.

Dynamic Stability

33. Dynamic stability characteristics of the Model 369C helicopter were determined under the conditions listed in table 2, appendix C. The objective of the dynamic stability tests was to evaluate the helicopter response characteristics following a gust disturbance. Gust disturbances were simulated by making pulse-type control inputs for 0.5 second. Following the input, the control was returned to trim, and all controls were held fixed until either the helicopter motions damped or recovery action was required. Releases from maximum steady-heading sideslips were also evaluated. Representative time histories of the dynamic stability characteristics of the Model 369C helicopter at 137 KCAS are presented in figures 29 through 31, appendix G.

Longitudinal:

34. Testing was accomplished in calm air, and the longitudinal pulse was used to simulate a gust disturbance. The dynamic longitudinal stability characteristics of the Model 369C were similar to the OH-6A at 105 KCAS. Pitch oscillations were damped within 10 seconds for an aft input and within 7 seconds for a forward input. Pitch-roll coupling was observed, but the roll oscillations dampened at approximately the same time as the pitch oscillations. At 137 KCAS, dynamic longitudinal stability could not be determined for aft control inputs due to the rapid buildup of normal acceleration (g). As illustrated in figure C and as presented in figure 29, appendix G, longitudinal control was returned to trim for 0.8 second, but normal acceleration continued to build to 1.5g within 1.5 seconds. Flight in turbulent air at 137 KCAS required extensive pilot compensation for adequate performance (HQRS 6). The excessively rapid buildup of normal acceleration following a simulated longitudinal gust disturbance is a shortcoming, correction of which is desirable if the helicopter is considered for procurement. Further testing is recommended to evaluate the effects of cg and altitude changes.

Lateral:

35. The oscillations created by the lateral pulse inputs were well damped at 105 KCAS, and lateral stability characteristics of the Model 369C and the OH-6A appear to be similar at this airspeed. As in the OH-6A, yaw and pitch rates were generated by the lateral input, and these rates increased as airspeed was increased

to 137 KCAS. A representative time history is presented in figure 30. This coupling about the helicopter's three axes at 137 KCAS, due to a lateral gust disturbance, increased pilot workload in turbulent wind conditions (HQRS 3) but was not objectionable. Within the scope of this test, the dynamic lateral stability of the Model 369C is satisfactory.

FLT COND	DENSITY ALTITUDE	GROSS WEIGHT	ROTOR SPEED	AFT CG LOCATION	AIR SPEED
<u> </u>	<u>~FT</u>	<u>~LB</u>	<u>~RPM</u>	<u>~IN.</u>	<u>~KCAS</u>
LEVEL	2490	3070	510	104.1	137

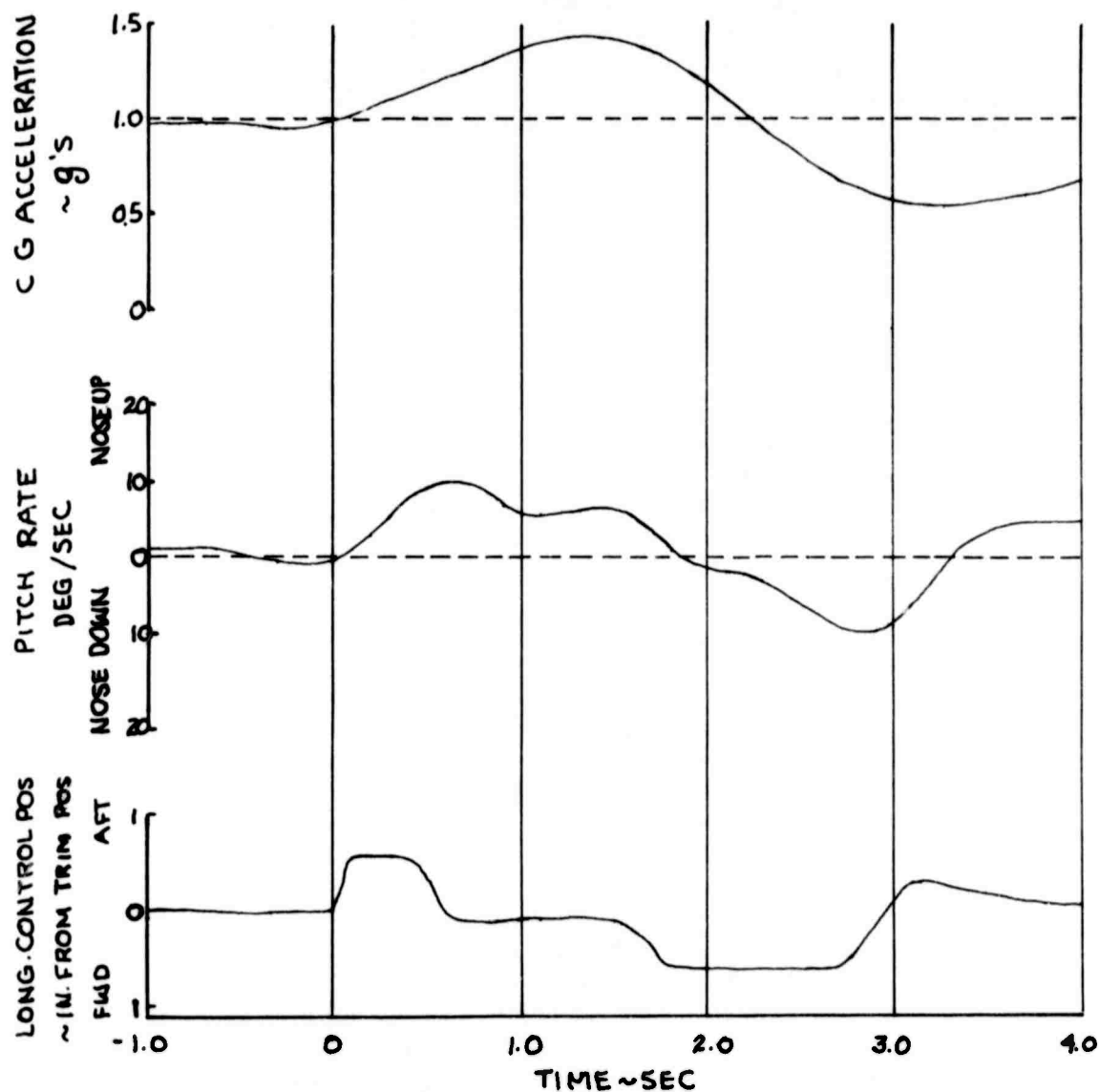


Figure C. Aircraft Response Following an Aft Longitudinal Pulse.

Directional:

36. The oscillations created by directional pulses and releases from maximum sideslips were satisfactorily damped at 105 KCAS. A yaw-pitch-roll coupling was experienced, but the resulting oscillations were damped within 5 seconds. The dynamic directional stability of the Model 369C and the OH-6A at 105 KCAS appear to be similar with yaw-pitch-roll coupling an undesirable characteristic during flights in turbulence.

37. At 137 KCAS, the initial coupled response of the helicopter became more severe as illustrated in figure 31, appendix G. A right directional pulse of approximately 1 inch held for 0.5 second produced a right yaw rate of 18 degrees per second (deg/sec) and a right roll rate of 20 deg/sec. A nose-down pitch rate was also generated but was not severe. The high roll rate caused the pilot to take corrective action with left lateral control approximately 0.3 second after applying the pulse. Corrective inputs of lateral control were required for 3 seconds before the roll and yaw rates had subsided, and the pilot felt he could hold all three controls fixed and let the oscillations dampen. This action resulted in the residual oscillations damping within 3 seconds. The dynamic directional stability of the Model 369C helicopter could not be determined at 137 KCAS due to the severity of the coupled response. Flight at this airspeed in turbulent wind conditions required extensive pilot compensation for adequate performance (HQRS 6). The excessive roll response of the Model 369C at 137 KCAS following a simulated directional gust disturbance is a shortcoming, correction of which is desirable if the helicopter is considered for procurement. Further testing should be conducted to evaluate the effect of cg and altitude change.

Controllability

38. Controllability characteristics of the Model 369C helicopter were evaluated under the conditions listed in table 2, appendix C, and the test results are presented in figures 32 through 37, appendix G. The helicopter was stabilized at the test conditions and single-axis control step inputs were applied to the longitudinal, lateral, and directional controls using a mechanical fixture to obtain the desired control input size. The step inputs were held steady and the helicopter response recorded for a specified time or until recovery action was initiated by the pilot. There was no objectionable delay in the development of angular velocity, and angular acceleration was in the direction commanded and occurred within 0.2 second after control displacement.

Longitudinal:

39. Longitudinal controllability characteristics are presented in figures 32 and 33, appendix G. In a hover, the longitudinal control response (maximum rate per inch of control displacement) could not be determined because the pitch rate had not peaked when recovery was initiated. Recovery was dictated by excessive nose-high and nose-low attitudes in close proximity to the ground. Pitch rate was measured at 0.8 second and was 13 deg/sec/in., nose down, and 17 deg/sec/in., nose up.

At 105 KCAS, maximum pitch rate was attained at approximately 0.9 second at the light gross weight (2360 pounds), and control response was 12 deg/sec/in., nose down, and 14 deg/sec/in., nose up. These control response values are essentially the same as the OH-6A data presented in reference 4, appendix A. An increase in gross weight to 2990 pounds at the same airspeed (105 KCAS) resulted in the same control response for a forward input: 12 deg/sec/in., nose down. Longitudinal control response for aft inputs could not be achieved because recovery was necessary prior to attaining maximum pitch rate. Recovery was dictated by blade stall which was characterized by a 5/rev vibration of the entire aircraft and an increase in longitudinal pitch rate, nose up (pitch up). Pitch rate was measured at 1.0 second and was 10 deg/sec for a maximum aft input of 0.8 inch. Because of excessive response, an aft input greater than 0.8 inch was not attempted. At 137 KCAS, longitudinal control response could not be attained for either a forward or aft input. Recovery was again dictated by blade stall, and the pitch rate was measured at 0.8 second. The maximum pitch rate attained at 0.8 second was 14 deg/sec for an 0.80-inch forward input and 9 deg/sec for a 0.55-inch aft step input. The longitudinal control response of the Model 369C helicopter was satisfactory in a hover but at the forward flight conditions was excessive and contributed a tendency to overcontrol and to drive the aircraft into blade stall. Combined with the neutral static longitudinal stability and neutral maneuvering stability discussed in paragraphs 30 and 46, the longitudinal control response increased the pilot workload considerably (HQRS 5).

40. Control sensitivity (maximum angular acceleration per inch of control displacement) in a hover was 24 deg/sec²/in., nose down and nose up. At 105 KCAS and light gross weight (2360 pounds), control sensitivity was 20 deg/sec²/in., nose down, and 23 deg/sec²/in., nose up. These values were essentially the same as the OH-6A data presented in reference 4, appendix A. At the heavier gross weights and at 105 KCAS and 137 KCAS, control sensitivity at 1 inch could not be ascertained due to blade stall, as explained in the previous paragraph. Within the scope of this test, the excessive longitudinal control response and sensitivity of the Model 369C at high airspeeds is a shortcoming, correction of which is desirable if the helicopter is considered for procurement. Further testing should be conducted to determine the effects of altitude and cg changes.

Lateral:

41. Lateral controllability characteristics are presented in figures 34 and 35, appendix G. In a hover, the lateral control response was 24 deg/sec/in., left, and 22 deg/sec/in., right. At 105 KCAS, control response was approximately the same for both the heavy (2990 pounds) and the light (2360 pounds) gross weight at 24 deg/sec/in., left, and 24 to 28 deg/sec/in., right. Lateral control response of the Model 369C helicopter appears to have increased slightly in comparison with the OH-6A but is satisfactory. At 137 KCAS, lateral control response had increased to 31 deg/sec/in., left, and approximately 40 deg/sec/in., right. As with the OH-6A, the Model 369C failed to meet the requirements of paragraph 3.3.15 of MIL-H-8501A but was satisfactory.

42. Lateral control sensitivity in a hover was 80 deg/sec²/in., left, and 74 deg/sec²/in., right. At 105 KCAS and at both gross weights, control sensitivity was approximately 70 deg/sec²/in., left, and 63 deg/sec²/in., right. Lateral control sensitivity appears to have also increased slightly in comparison with the OH-6A but is satisfactory. At 137 KCAS, control sensitivity had increased to approximately 84 deg/sec²/in., left, and 98 deg/sec²/in., right. Both the lateral control response and sensitivity of the Model 369C helicopter caused some overcontrolling of the helicopter (HQRS 3). The tendency to overcontrol due to the response of the Model 369C to lateral control deflection failed to meet the requirement of paragraph 3.3.15 of MIL-H-8501A, but was satisfactory. Within the scope of these tests, the lateral control response and sensitivity of the Model 369C are satisfactory.

Directional:

43. Directional controllability characteristics are presented in figures 36 and 37, appendix G. In a hover, the directional control response could not be determined because the yaw rate had not peaked when recovery was initiated. Recovery was initiated after approximately 1.5 seconds. Yaw rate was measured at 1.0 second and was 32 deg/sec/in., left and right. At 105 KCAS and light gross weight (2360 pounds), maximum yaw rate was attained at approximately 0.6 second and was 24 deg/sec/in., left, and 20 deg/sec/in., right. These control response values are essentially the same as those of the OH-6A. Directional control response was not attained for control displacements larger than 0.75 inch at 105 KCAS at the heavy gross weight (2990 pounds) due to a control fixture malfunction, but it appears that the values at 1 inch would not have changed as a result of the additional weight. At 137 KCAS, control response could not be attained for control displacements larger than 0.8 inch without exceeding helicopter sideslip limits, but it appears the values would not have changed as a result of increased speed above 105 KCAS.

44. Directional control sensitivity at a hover was 34 deg/sec²/in., left and right. At 105 KCAS and at both gross weights, control sensitivity was approximately 50 deg/sec²/in., left, and 41 deg/sec²/in., right, and is essentially the same as the OH-6A. At 137 KCAS, these values appear to have been unchanged. The directional controllability of the Model 369C helicopter was high and caused some overcontrolling, especially in high or gusty winds (HQRS 3). The tendency to overcontrol due to the response of the Model 369C to directional control deflections failed to meet the requirement of paragraph 3.3.7 of MIL-H-8501A but was satisfactory. Within the scope of these tests, the directional response and sensitivity of the Model 369C helicopter are satisfactory.

Maneuvering Stability

45. Maneuvering stability tests were conducted to determine the variation of longitudinal control position with normal acceleration for the conditions listed in table 2, appendix C. Test results are presented in figure 38, appendix G. The test technique was to perform collective-fixed steady turns. The aircraft was first

stabilized at the desired trim airspeed in level flight, and then airspeed was maintained at increasing increments of bank angle in coordinated turns, left and right.

46. The helicopter exhibited positive maneuvering stability at 105 KCAS up to 1.8g. As the load factor was increased, increasing aft longitudinal control was required. At 135 KCAS, however, maneuvering stability was neutral, and maximum load factor could not be obtained since blade stall was encountered at approximately 1.2g, left and right. Extensive pilot effort would be required during operational maneuvers at this airspeed (HQRS 6). The effects of neutral maneuvering stability can be seen in figure C, where normal acceleration continued to build after the longitudinal control was returned to the trim condition. A control reversal was required to stop the buildup, and an even greater reversal was required to arrest the overshoot in the opposite direction. Neutral maneuvering stability of the Model 369C helicopter and tendency to encounter blade stall at airspeeds approaching VH required extensive pilot compensation during maneuvering tasks at high airspeeds (HQRS 6) and is a shortcoming, correction of which is desirable if the helicopter is procured. The following "CAUTION" should be included in the appropriate operator's manual:

CAUTION

Abrupt longitudinal control movement or roll attitudes in excess of 30 degrees, left and right, at airspeeds approaching maximum level flight may cause blade stall and should be avoided.

Additional testing should be conducted to determine the effects of altitude, weight, and cg change on the maneuvering stability characteristics of the Model 369C helicopter.

Autorotational Entry and Descent Characteristics

47. Simulated engine failure tests (throttle chops) were conducted to determine the adequacy of pilot cues, identify the recovery techniques required to establish autorotation, and to determine the safe delay time prior to corrective action. The tests were conducted under the conditions listed in table 2, appendix C. Time histories for two representative flight conditions are presented in figures 39 and 40, appendix G. The tests were conducted by first stabilizing the helicopter in coordinated level flight and then rapidly rotating the throttle to the ground-idle position. All controls were held fixed for a specified time or until recovery action was dictated by a critical parameter.

48. Engine failure cues were evaluated at all test conditions. These cues were a change in engine sound, a decrease in rotor rpm, and a change in the helicopter attitude. The initial aircraft response was an immediate yaw to the left, followed closely by left roll and a very slight pitch down. An engine-out warning light was available but not evaluated because actual engine failures were not tested. The engine failure cues of the Model 369C helicopter are satisfactory.

49. The recovery technique following throttle chops was similar for all conditions. The collective control was smoothly lowered, and right lateral cyclic and right pedal were applied. Upon lowering the collective stick, a pitch down occurred, and aft cyclic was required. The downward pitching rate and amount of aft cyclic required were functions of airspeed and not power, as indicated in figures 39 and 40, appendix G. The excessive pitch and roll attitudes that occurred in the OH-6A (ref 4, app A) at airspeeds in excess of 110 KCAS were not found to be present in the Model 369C helicopter. Recovery techniques following a simulated engine failure are considered to be satisfactory.

50. In the OH-6A, variations in trim of up to 4 inches of aft longitudinal control and 5 inches of right lateral control were required for transition from level flight to autorotational descent. In the Model 369C helicopter, the trim changes were found to be reduced to approximately 2 inches of aft longitudinal control and 1 inch of right lateral control. This reduction in control trim change is a significant improvement in the Model 369C relative to the OH-6A. Cyclic control position changes during autorotational entry and descent in the Model 369C are satisfactory.

51. The time available for pilot recognition and reaction to sudden engine failure (delay time) was determined for all test conditions. The critical parameter was rotor rpm. The contractor would not define a safe minimum transient rotor rpm, therefore, the pilot, in a buildup program, selected 450 as recovery rpm. The minimum transient rotor rpm encountered was approximately 445 due to the quick response of the rotor to recovery action. A drop in engine torque was the only available cue for determination of the throttle chop from the onboard data acquisition system. Delay times for maximum power climbs averaged 1 second, while delay times in level flight ranged from 1.8 seconds at 60 KCAS to 1 second at 137 KCAS. Because of a possible error in recorded delay time due to inadequate instrumentation and slow engine torque bleed-off, further testing should be conducted to develop height-velocity curves and to evaluate the effect of the rate of decrease of engine torque on autorotational entry characteristics. A qualitative throttle chop was performed at 150-KIAS descending flight but recovered as soon as possible to minimize the chance of exceeding VNE. The delay time available following a simulated engine failure of the Model 369C helicopter is satisfactory.

52. Autorotational descent characteristics were evaluated during both the autorotational descent performance (para 16) and simulated engine failure testing (paras 47 through 50). At the high gross weights tested, full-down collective resulted in a rapid buildup of rotor rpm. This rapid buildup of rpm required considerable pilot attention to prevent overspeeding the rotor during the initial entry phase of the autorotation (HQRS 4). During descent, collective pitch was continually adjusted to maintain a desired rpm since small variations in airspeed and/or altitude resulted in large variations in rotor rpm. This characteristic is identical to the OH-6A and increases pilot workload (HQRS 4). The excessive pilot workload required to control rotor speed in autorotation is a shortcoming, correction of which is desirable if the helicopter is procured.

Takeoff Characteristics

53. Takeoff characteristics were evaluated throughout the test. During transition and acceleration from hover to forward flight, a nose-up pitching moment was produced by upward motion of the collective control. This coupling was not objectionable, but the pilot was unable to trim out the longitudinal control forces required to maintain the desired takeoff flight path for approximately 5 seconds (HQRS 3). This characteristic was present in the OH-6A. Although the Model 369C trim system incorporated a faster trim motor than the OH-6A trim system, this trim motor did not provide a trim rate large enough to equal the longitudinal trim requirement of the Model 369C during takeoff. This slow rate in trimming longitudinal control forces encountered during takeoff is only mildly unpleasant (HQRS 3). Within the scope of this test, takeoff flight characteristics of the Model 369C are satisfactory.

Decelerating Flight Characteristics

54. Decelerating flight characteristics of the Model 369C helicopter were evaluated throughout the test program. During deceleration from high airspeeds (100 to 140 KIAS) to a hover, both the engine and rotor exceeded the upper limit of the normal power-ON operating speed range (103 percent). A level deceleration from 120 KIAS at 103-percent N₂ to a hover was conducted to further evaluate this characteristic. During this deceleration, the engine governor beeper trim switch was not used, in order to duplicate normal operational technique. The rotor and engine speed increased to 107-percent N₂ before the pilot took corrective action to prevent a further increase which could have resulted in damage to the aircraft. This minor but annoying aircraft characteristic requires moderate pilot compensation for desired engine and rotor control during deceleration (HQRS 4). This engine and rotor overspeed characteristic during deceleration from high airspeeds is a shortcoming, correction of which is desirable if the helicopter is procured.

55. During deceleration from any airspeed to a hover, a 5/rev vibration was felt throughout the entire aircraft and was most noticeable in the directional pedals. This vibration was uncomfortable and distracting to the pilot and is a shortcoming, correction of which is desirable if the helicopter is procured.

High-Speed Flight Characteristics

56. Flights at 137 KCAS (V_H) and 150 KCAS (V_{NE}) were evaluated at the maximum design gross weight of 3150 pounds at both an aft and slightly forward cg at a density altitude of 2400 feet. Two qualitative flights were conducted with an operational Army pilot who was experienced in the OH-6A helicopter. This pilot either contributed or concurred with the qualitative comments in the following paragraphs.

57. At V_H, the neutral maneuvering stability (para 46), the neutral static longitudinal stability (para 30), the excessive longitudinal control response and

sensitivity (paras 39 and 40), and the poor flying qualities in turbulence (paras 35 through 39) created an unusually high pilot workload (HQRS 5). Reducing the airspeed to approximately 133 KCAS and ballasting to a cg location of fuselage station (FS) 99.0 (forward) improved the flying qualities to an acceptable level and is the airspeed and cg combination recommended for high speed operation. This airspeed, however, cannot be maintained longer than 5 minutes due to the transmission limitation. Flight above 133 KCAS should be performed only when warranted, as considerable pilot compensation is necessary for adequate performance (HQRS 5). Further testing at different altitudes and cg conditions should be conducted to fully evaluate the Model 369C flight characteristics at V_H .

58. Flight at 150 KCAS (V_{NE}) required maximum-allowable power and a rate of descent varying from 500 to 700 ft/min. The adverse handling qualities exhibited at 137 KCAS were worse at 150 KCAS. Moving the cg forward to FS 99.0 improved flying qualities, but they were still marginal. Blade stall was encountered at this airspeed at bank angles of 30 degrees (1.2g), left and right. Flight at 150 KCAS (V_{NE}) requires extensive pilot compensation for adequate performance (HQRS 6). The limited maneuvering capability and the objectionable handling qualities at 150 KCAS limit the operational capability of the helicopter. Further testing should be conducted to evaluate the effect of altitude and cg change on the flying qualities of the Model 369C at V_{NE} .

MISCELLANEOUS

Airspeed Calibration

59. The standard airspeed system was not installed on the aircraft. An airspeed calibration was performed on the boom system at the conditions listed in table 1, appendix C, and the test results are presented in figure 41, appendix G. A measured ground course was flown in calm air from 30 KIAS to V_H . Calibration should be performed on the helicopter standard airspeed system when installed.

Weight and Balance

60. The test helicopter, S/N 65-12951, was weighed by HTC-AD prior to starting the test program. The weighing was accomplished in a closed hangar with mechanical weighing scales placed under the aircraft skids. The basic weight (empty aircraft plus full hydraulic fluid and trapped fuel) was 1344 pounds. After the instrumentation was installed and fuel and oil added, the test aircraft weighed 2155 pounds, and the cg location was FS 106.85.

CONCLUSIONS

GENERAL

61. The following conclusions were reached at the completion of the Army Preliminary Evaluation of the Hughes Model 369C helicopter:

- a. Hover performance is improved as compared to the OH-6A (para 13).
- b. Level flight speed capability is improved as compared to the OH-6A (para 14).
- c. Removing the maximum-continuous transmission limit of 278 shp will enable the Model 369C to achieve substantially higher airspeeds in level flight at sea level (para 14).
- d. Within the OH-6A speed range, the static and dynamic stability and controllability of the Model 369C and OH-6A are essentially the same (paras 30, 32, 34, 35, 36, 39, 40, 41, 42, 43, and 44).
- e. Handling qualities of the Model 369C are degraded at airspeeds that exceed the envelope of the OH-6A (paras 30, 34, 37, 39, 40, and 46).
- f. Autorotational entry characteristics and trim changes between level flight and autorotation are improved compared to the OH-6A (paras 49 and 50).
- g. The limited maneuvering capability and the objectionable handling qualities at 150 KCAS limit the operational capability of the Model 369C helicopter (para 58).
- h. There was one deficiency and 12 shortcomings identified during the evaluation.

DEFICIENCY AND SHORTCOMINGS

62. Correction of the inadequate longitudinal control margin deficiency observed during left sideward and rearward flight at a forward cg loading is mandatory if the helicopter is procured (paras 21 and 23).

63. Correction of the following shortcomings is desirable if the helicopter is procured:

- a. Directional instability in left sideward flight (HQRS 4) (para 20).
- b. Directional instability in rearward flight (HQRS 4) (para 22).

- c. Excessive left pedal force during hover (HQRS 4) (para 26).
- d. Excessive pilot workload required to perform precision hovering tasks (HQRS 5) (para 28).
- e. Neutral static longitudinal stability in the airspeed band of 130 KCAS to maximum level flight (HQRS 5) (para 30).
- f. Excessively rapid buildup of normal acceleration following a simulated longitudinal gust disturbance (HQRS 6) (para 34).
- g. Excessive roll response of the helicopter at 137 KCAS following a simulated directional gust disturbance (HQRS 6) (para 37).
- h. Excessive longitudinal control response and sensitivity at high airspeeds (HQRS 5) (paras 39 and 40).
- i. Neutral maneuvering stability and tendency to encounter blade stall at airspeeds approaching maximum level flight (HQRS 6) (para 46).
- j. Excessive pilot workload required to control rotor speed in autorotation (HQRS 4) (para 52).
- k. Unsatisfactory engine and rotor overspeed characteristic during deceleration from high airspeeds (HQRS 4) (para 54).
- l. Excessive 5/rev vibration of the aircraft during deceleration to a hover (para 55).

MILITARY SPECIFICATION COMPLIANCE

64. Within the scope of this test, the Hughes Model 369C helicopter failed to meet the following requirements of the military specification, MIL-H-8501A:

- a. Paragraph 3.2.1 - Inadequate control remains to counteract longitudinal disturbances (paras 21 and 23).
- b. Paragraph 3.3.12 - Maximum left pedal force of 15 pounds was exceeded by 10 pounds, or 67 percent (para 26).
- c. Paragraph 3.2.10 - The helicopter did not, at all forward speeds, exhibit positive static longitudinal stability (para 30).
- d. Paragraph 3.3.15 - The maximum rate of roll per inch of sudden control deflection exceeded 20 deg/sec by 100 percent (para 41).
- e. Paragraph 3.3.15 - The tendency to overcontrol due to the response of the Model 369C to lateral control deflection (para 42).

f. Paragraph 3.3.7 - The tendency to overcontrol due to the response of the Model 369C to directional control deflection (para 44).

RECOMMENDATIONS

65. If procurement is planned, the deficiency, correction of which is mandatory, should be corrected prior to any airworthiness release of the Hughes Model 369C helicopter for flight at a forward cg by operational pilots (para 62).

66. If procurement is planned, the shortcomings, correction of which is desirable, should be corrected prior to production (para 63).

67. The following "CAUTION" should be included in the operator's manual (para 46):

CAUTION

Abrupt longitudinal control movement or roll attitudes in excess of 30 degrees, left and right, at airspeeds approaching maximum level flight will cause blade stall and should be avoided.

68. The following "NOTE" should be included in the operator's manual (para 25):

NOTE

The fuel control system overcompensates for rotor droop as collective pitch is increased and may result in overspeeding the engine.

69. Main rotor dampers, HTC-AD part number 369ASK1933, should be installed if considered for procurement (para 27).

70. The helicopter standard airspeed system should be calibrated when installed (para 59).

71. Further testing should be conducted to:

a. Evaluate the effects of altitude, weight, and cg variation (paras 13, 16, 23, 30, 34, 37, 40, 46, 57, and 58).

b. Determine a safe operational cg envelope for hovering in winds (para 23).

c. Develop height-velocity curves (para 51).

d. Evaluate the effect of the rate of decrease of engine torque on autorotational entry characteristics (para 51).

APPENDIX A. REFERENCES

1. Letter, AVSCOM, AMSAV-EF, 2 September 1971, subject: Hughes 369C Evaluation.
2. Operator's Manual, TM 55-1520-214-10, *Helicopter, Observation OH-6A (Hughes)*, July 1969.
3. Report, Hughes Tool Company, Aircraft Division, HTC-AD 369-X-8032A, *OH-6C Demonstration - Prototype, Safety of Flight Review*, 20 August 1971.
4. Final Report, USAASTA, Project No. 65-37, *Engineering Flight Test of the OH-6A Helicopter (Cayuse), Phase D*, April 1969.
5. Military Specification, MIL-H-8501A, *Helicopter Flying and Ground Handling Qualities; General Requirements For*, 7 September 1961, with Amendment 1, 3 April 1962.
6. Flight Test Manual, Naval Air Test Center, USNTPS-FTM-No. 102, *Helicopter Performance*, 28 June 1968.
7. Flight Test Manual, Naval Air Test Center, USNTPS-FTM-No. 101, *Helicopter Stability and Control*, 10 June 1968.

APPENDIX B. GENERAL AIRCRAFT AND COMPONENT DESCRIPTION AND PHOTOGRAPHS

FUSELAGE AND LANDING GEAR DIMENSIONS

Same as the OH-6A helicopter

"T" TAIL

Horizontal Stabilizer

Span	5.15 ft
Tip chord	0.71 ft
Root chord	1.40 ft
Area	5.43 ft ²
Airfoil (root)	NACA 6518
Airfoil (tip)	NACA 6515

Upper Vertical Stabilizer

Span	3.52 ft
Tip chord	0.83 ft
Root chord	1.18 ft
Area	3.54 ft ²
Airfoil (tip)	NACA 0021
Trailing edge tab	25-percent chord, T.E. left 3 deg

Lower Vertical Stabilizer

Span	2.50 ft
Tip chord	0.53 ft
Root chord	1.18 ft

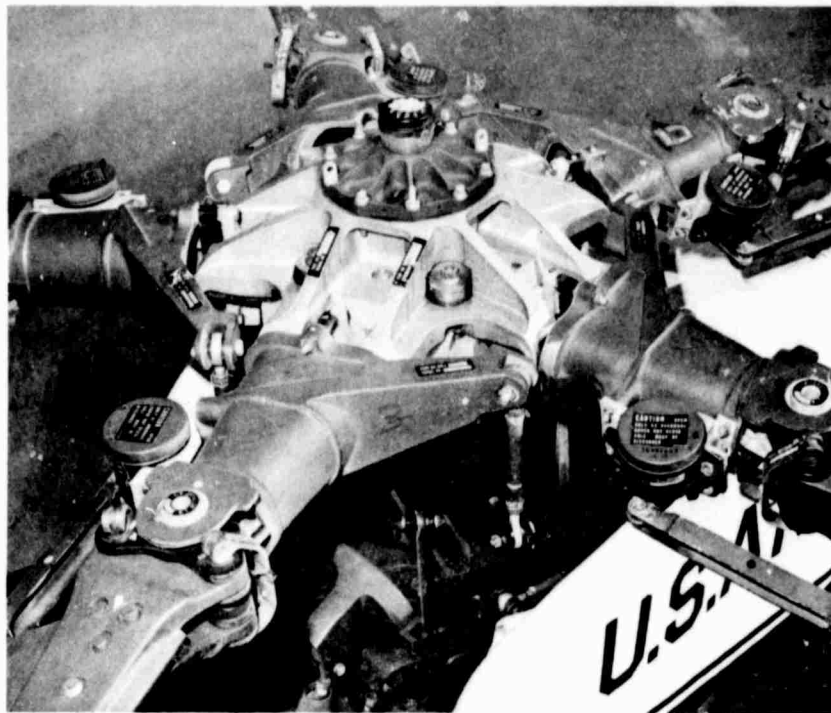


Photo 1. Five-Blade Main Rotor Hub.

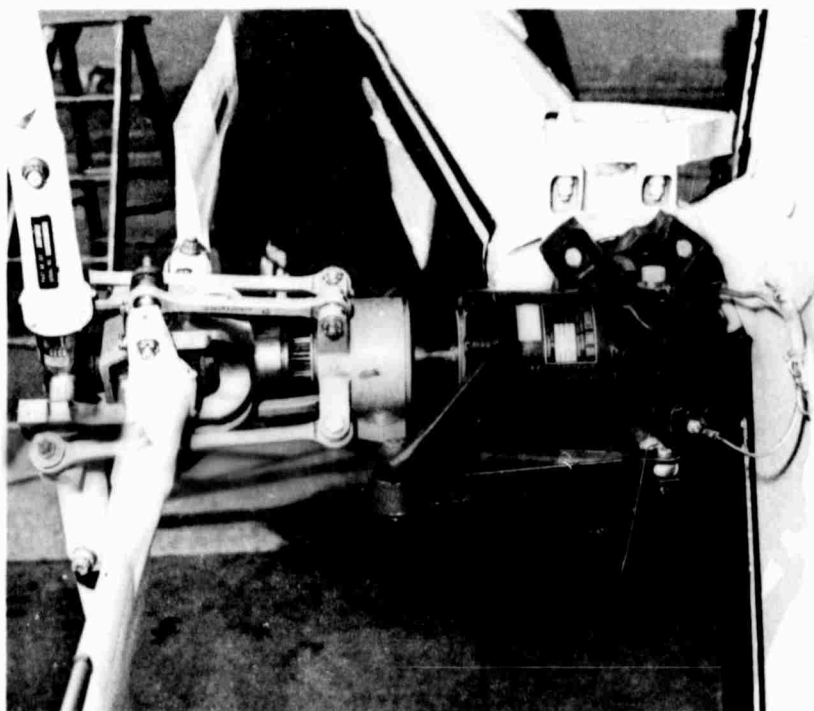


Photo 2. Four-Blade Tail Rotor and Gearbox.

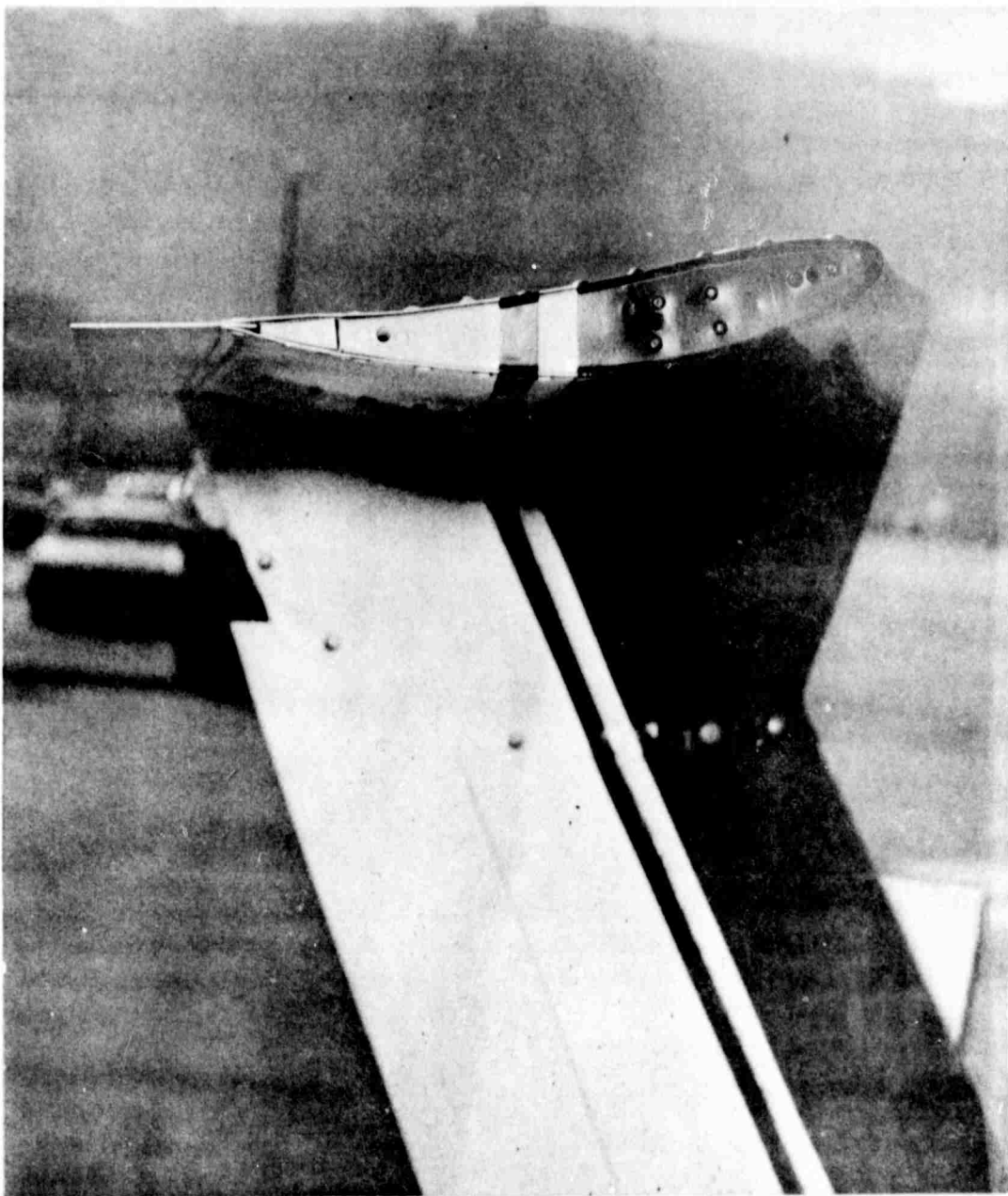


Photo 3. T-Tail.

Area	2.14 ft ²
Airfoil (tip)	NACA 0012

TAIL BOOM STRUCTURE

Basic boom skin thickness	0.040 in.
Upper and lower boom centerlines	Additional hat-section stringers
Boom to aft fuselage junction	External brackets added
Landing gear	Strengthened over OH-6A (includes a swivel feature to reduce pitching velocity)

MAIN ROTOR CHARACTERISTICS

Number of blades	5
Rotor diameter	26.41 ft
Rotor disc area	547.94 ft ²
Blade chord (constant)	0.562 ft
Blade twist (root to tip)	9 deg
Blade area (total blades x c x R)	37.13 ft ²
Solidity ratio	0.068
Airfoil section	NACA 0015
Delta three	Zero deg
Droop stop flapping	-6 deg
Droop stop coning (static)	Zero deg
Droop stop coning (rotating)	-2 deg

Built-in collective pitch at 3/4R (straps untwisted)	8 deg
Equivalent flapping hinge offset	6 in.

TAIL ROTOR CHARACTERISTICS

Number of blades	4 (two 2-bladed rotors)
Rotor diameter	4.83
Rotor disc area	18.34 ft ²
Blade chord (constant)	0.40 ft
Blade twist (root to tip)	8 deg
Blade area (total blades x c x R)	3.872 ft ²
Solidity ratio	0.204
Airfoil section	NACA 63-415 modified
Delta three	30 deg
Droop stop flapping limits	10 deg, soft 15 deg, hard

MAIN ROTOR BLADE MOVEMENTS (Blade angles measured on pitch housing)

Average range of cyclic pitch blade angles from neutral rigging position (collective pitch, mid position)	16.90 deg, forward 8.00 deg, aft 9.00 deg, left 6.85 deg, right
Average range of collective pitch blade angles from neutral collective	7.80 deg, up 7.80 deg, down

TAIL ROTOR BLADE MOVEMENTS

Average range of directional pitch
blade angles from neutral

12.52 deg, right
28.55 deg, left

FLIGHT CONTROLS GROUP

(Same as OH-6A helicopter below the rotating swashplate except for a minor modification in the collective bungee)

CONTROL TRAVEL

(Same as OH-6A helicopter)

TRANSMISSION DRIVE SYSTEM RATIOS

Engine to main rotor	12.121:1
Engine to tail rotor	2.9703:1
Engine to tail rotor drive shaft	2.765:1
Allison turboshaft engine (model 250-C20)	400 shp

APPENDIX C. TEST CONDITIONS

Table 1. Performance Test Conditions of the Hughes Model 369C, S/N 65-12951.

Test Condition	Indicated Airspeed (kt)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Outside Air Temperature (°C)	Average Center-of-Gravity Location (in.)	Rotor Speed (rpm)
Airspeed calibration	31 to 145	3,080	800	19.8	104.0 (aft)	510
Level flight performance: ($C_T = 0.004088$) ($C_T = 0.004838$) ($C_T = 0.005920$) ($C_T = 0.006752$)	31 to 131	2,420	3,100	25.5	101.1 (mid)	510
	30 to 137	2,930	2,290	24.5	104.1 (aft)	510
	30 to 122	3,090	7,190	24.0	101.0 (mid)	510
	35 to 105	3,070	11,540	18.5	101.0 (mid)	510
IGE hover performance	Hover	Note ¹	600	19.5	101.0 (mid)	505 and 510
OGE hover performance	Hover	Note ¹	600	19.5	101.0 (mid)	505 and 510
Autorotational descent	29 to 100	3,050	1,900	18.0	104.0 (aft)	510
Autorotational descent	60	3,100	2,240	21.0	104.1 (aft)	465 to 428

¹Minimum gross weight plus varying cable tension.

Table 2. Handling Qualities Test Conditions of the Hughes Model 369C, S/N 65-12⁵51.

Rotor Speed: 510 rpm

Test Condition	Flight Condition	Indicated Airspeed (kt)	Average Gross Weight (lb)	Average Density Altitude (ft)	Average Outside Air Temperature (°C)	Average Center-of-Gravity Location (in.)
Trim control characteristics	Level	40 to 140	3100	2380	30.0	104.0 (aft)
	Climb ¹	30 to 90	3050	1900	18.0	104.0 (aft)
	Sideward IGE	35 left to 35 right	3120	860	20.5	96.9 (fwd)
	Rearward IGE	Zero to 30	3160	900	21.0	96.9 (fwd)
Static longitudinal stability	Level	51, 109, and 140	3100	2400	25.0	104.1 (aft)
Static lateral-directional stability	Level	52, 81, 106, and 139	3100	2370	25.0	104.1 (aft)
	Level	105	2440	2400	19.0	103.9 (aft)
Critical wind determination	Level	Hover	3160	980	22.5	103.9 (aft)
Maneuvering stability	Level	106 and 138	3050	1850	20.0	104.1 (aft)
Longitudinal control response and dynamic stability	Level	Hover	3100	1080	22.0	104.1 (aft)
	Level	105 and 140	3050	2450	29.0	104.1 (aft)
	Level	105	2360	2400	19.0	104.0 (aft)
Lateral control response and dynamic stability	Level	Hover	3060	1080	22.0	104.1 (aft)
	Level	105 and 140	3050	2400	29.0	104.1 (aft)
	Level	105	2360	2400	19.0	104.0 (aft)
Directional control response and dynamic stability	Level	Hover	3170	500	19.0	103.9 (aft)
	Level	105 and 140	3050	2450	26.0	104.1 (aft)
	Level	105	2360	2400	19.0	104.0 (aft)
Simulated engine failure	Level	30 to 150	3100	3260	22.0	104.1 (aft)
	Climb ¹	30 to 90	3050	2810	18.0	104.0 (aft)

¹Maximum power.

APPENDIX D. SAFETY-OF-FLIGHT RELEASE

AUG 25 02 38 '71

NNNPTTUZYUW RUWTTFA2752 2362251-UUUU--RUWJBDA.

ZNR UUUUU

PR 242200Z AUG 71

FM CG USAAVSCOM ST LOUIS MO

TO RUWJBDA/CO USAASTA EDWARDS AFB CALIF

INFO RUEBBNA/CG USAMC WASH DC

BT

UNCLAS

AMSAV-EFI

ACTION FOR SAVTE-P AMC FOR AMCRD-FQ AND AMCF5-FA

IN REPLY REFER TO: Ø8-15

SUBJECT: SAFETY OF FLIGHT RELEASE FOR 369C DEMONSTRATION

A. HUGHES TOOL CO, REPORT NO 369-X-8Ø32A, OH-6C DEMONSTRATION

PROTOTYPE SAFETY OF FLIGHT REVIEW, DATED 2Ø AUG 71.

1. THIS CONSTITUTES A SAFETY OF FLIGHT RELEASE FOR USAASTA TO CONDUCT AN EVALUATION OF THE HUGHES TOOL CO., AIRCRAFT DIV (HTC-AD) MODEL 369C.
2. THE OPERATING PROCEDURES AND LIMITATIONS OF THE MODEL 369C SHALL BE IN ACCORDANCE WITH THE TM 55-152Ø-214-1Ø EXCEPT AS MODIFIED BY THIS SAFETY OF FLIGHT RELEASE AND OPERATING PROCEDURES TO BE PROVIDED BY HTC-AD. HELICOPTER OPERATING LIMITATIONS ARE AS FOLLOWS:
 - A. INSTRUMENT MARKINGS - THE AIRCRAFT INSTRUMENT MARKINGS HAVE BEEN

PAGE 2 RUWTFFA2752 UNCLAS

CHANGED FROM A STANDARD OH-6A TO CONFORM TO THE APPLICABLE LIMITATIONS.

B. MAXIMUM TAKEOFF GROSS WEIGHT 3200 POUNDS.

C. C.G.LIMITS- REFERENCE HTC-AD REPORT 369-X-8032A, FIGURE 3.

D. MAXIMUM LOAD FACTORS - REFERENCE HTC-AD REPORT 369-X-8032A,
FIGURE 3.

E. AIRSPEED LIMITATIONS

VNE - 150 KCAS, SEA LEVEL, STANDARD DAY FOR PRESSURE

ALTITUDE VARIATIONS (REFERENCE HTC-AD REPORT
369-X-8032A, FIGURE 5)

F. MAIN ROTOR LIMITATIONS

(1) NORMAL POWER-ON OPERATING RANGE IS 102 to 103 PERCENT N2.

(2) POWERED FLIGHT, MAXIMUM 510 RPM, MINIMUM 505 RPM.

(3) AUTOROTATION, MAXIMUM 528 RPM, MINIMUM UNDER 2400 LBS
GW 400 RPM, OVER 2400 LBS GW 465 RPM.

G. ENGINE OUTPUT SHAFT SPEED (N2), 103 PER CENT N2EQUALS 6180RPM.

H. TORQUE PRESSURE, TAKEOFF POWER (5 MINUTES) 82.4 PSIG MAX,
CONTINUOUS 64.5 PSIG MAX.

I. TURBINE OUT TEMPERATURE, TAKEOFF POWER (5MINUTES) 793 DEGREE C,
CONTINUOUS 757 DEGREE C.

J. SIDESLIP ANGLE LIMITATIONS- REFERENCE HTC-AD REPORT 369-X-8032A,

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FIGURE 6. SIDEWARD FLIGHT IS LIMITED TO 35 KNOTS. REARWARD FLIGHT IS LIMITED TO 30 KNOTS.

K. FLIGHT OF THE HTC-AD MODEL 369C IS LIMITED TO AMBIENT TEMPERATURES OF LESS THAN 46 DEGREE C BECAUSE OF ENGINE OIL COOLING LIMITATIONS.

1. TOTAL FLIGHT HOURS OF THE HTC-AD MODEL 369C SHALL BE LIMITED TO 200 HOURS BECAUSE OF LIMITATIONS ON THE FATIGUE LIFE OF CERTAIN CRITICAL COMPONENTS.

3. THE FOLLOWING MAINTENANCE INSTRUCTIONS APPLY AS RESTRICTIONS TO THE OPERATION OF THE HTC-AD 369C.

A. THE TRIM TABS ON THE VERTICAL AND HORIZONTAL STABILIZERS SHALL NOT BE ADJUSTED UNLESS AUTHORIZED BY THE HTC-AD FLIGHT TEST PROJECT ENGINEER.

B. THE FOLLOWING COMPONENTS SHALL BE INSPECTED VISUALLY FOR EVIDENCE OF IMPENDING FAILURE SUCH AS UNUSUAL DISTORTION, CRACKS IN SHEET METAL, ENLARGED ATTACHMENT HOLES AND CRACKED MACHINED OR FORGED PARTS. SUSPICION OF POSSIBLE FAILURE OF THE PART(S) SHALL BE CAUSE FOR HALTING OF TEST FLIGHTS UNTIL A POSITIVE IDENTIFICATION CAN BE MADE.

(1) "T" TAIL ATTACHMENT FITTINGS AT THE JUNCTION OF OPERATION)

PAGE 4 RUWTFFA2752 UNCLAS

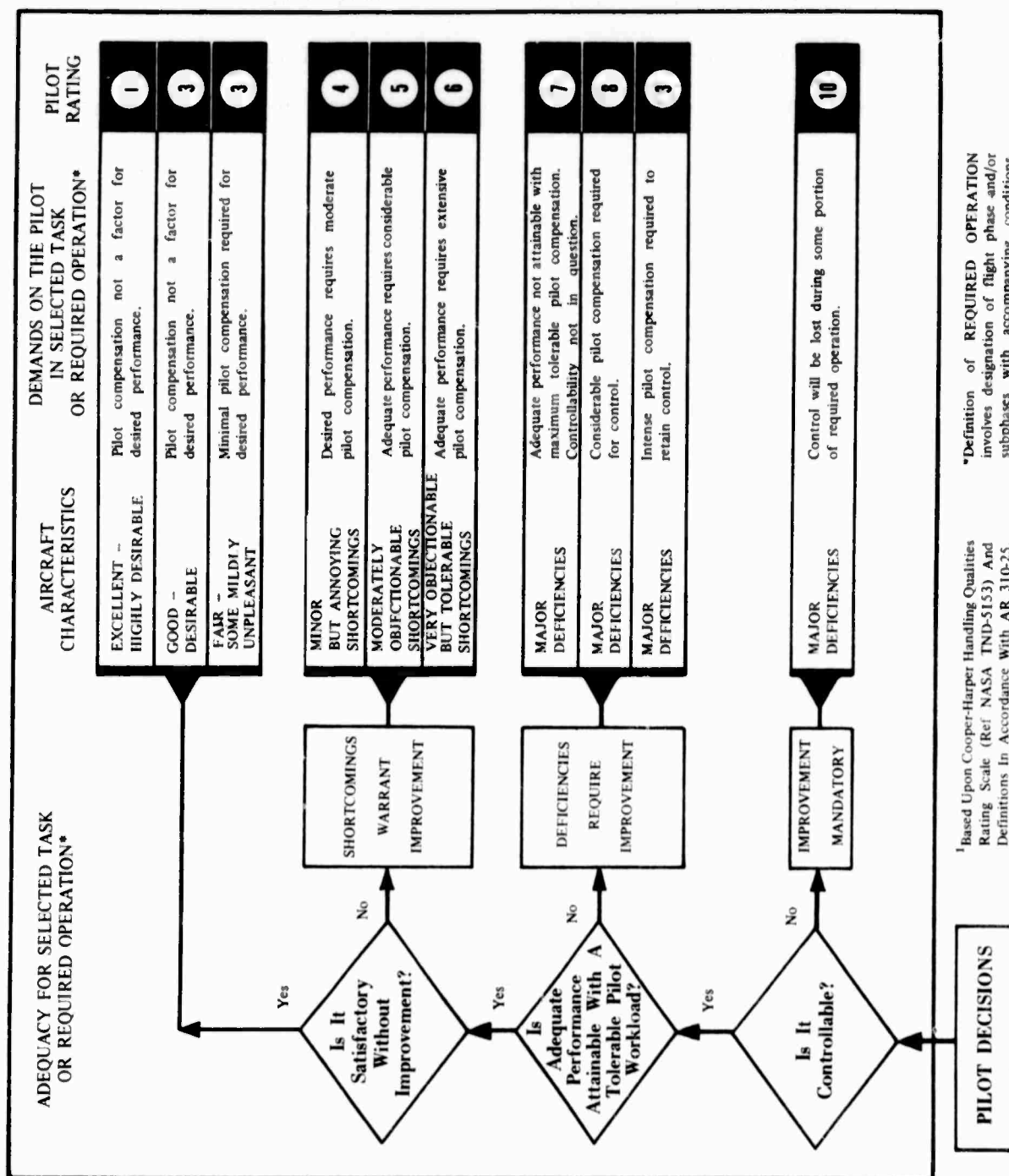
- (2) "T" TAIL ATTACHMENT FITTINGS TO TAIL BOOM (DAILY)
- (3) TAIL ROTOR FORK, PITCH LINKS AND ATTACHMENT HARDWARE (PREFLIGHT)
- (4) TAIL BOOM ASSEMBLY, AFT, AT THE TAIL ROTOR GEARBOX ATTACHMENT BULKHEAD. ALONG STIFFENERS AND AT TAIL BOOM SPLICES (DAILY)
- (5) ALL LOAD CARRYING STRUCTURE (SKIN AND FRAMES) ON THE AFT FUSELAGE (DAILY)
- (6) MAIN ROTOR HUB, BLADE ATTACHMENT FITTINGS, PITCH ARMS, DAMPER ARMS AND BLADE RETENTION STRAPS. ANY SINGLE LAMINATE FAILURE SHALL HALT TESTING (PREFLIGHT)

4. A VERIFICATION COPY OF THIS MESSAGE WILL BE FORWARDED BY MAIL

BT

2752

APPENDIX E. HANDLING QUALITIES RATING SCALE



APPENDIX F. TEST INSTRUMENTATION

OSCILLOGRAPH

Main rotor rpm
Longitudinal cyclic control position
Lateral cyclic control position
Directional pedal position
Collective control position
Angle of attack
Pitch rate
Roll rate
Yaw rate
Center-of-gravity normal acceleration
Engine torque pressure
Six-volt reference

COCKPIT

Rotor speed
Wet compass
Boom airspeed indicator
Altimeter indicator
Free air temperature
Exhaust gas temperature
Sensitive torque pressure
Power turbine speed
Gas producer speed
Center-of-gravity normal accelerometer
Fuel totalizer (available only during hover
and level flight performance tests

INSTRUMENT LOCATION

<u>Parameter</u>	<u>Fuselage Station</u>	<u>Water Line</u>	<u>Buttline</u>
Longitudinal cyclic control position	57.36	17.50	4.00 right
Lateral cyclic control position	61.36	20.00	8.00 right
Directional pedal position	43.60	18.50	3.75 right
Collective control position	74.50	23.10	24.00 left
Rate gyros	100.00	13.00	Zero
Center-of-gravity acceleration	105.00	23.25	Zero
Engine torque pressure	119.00	25.25	16.00 left
Airspeed	85.50	25.25	8.50 left

APPENDIX G. TEST DATA

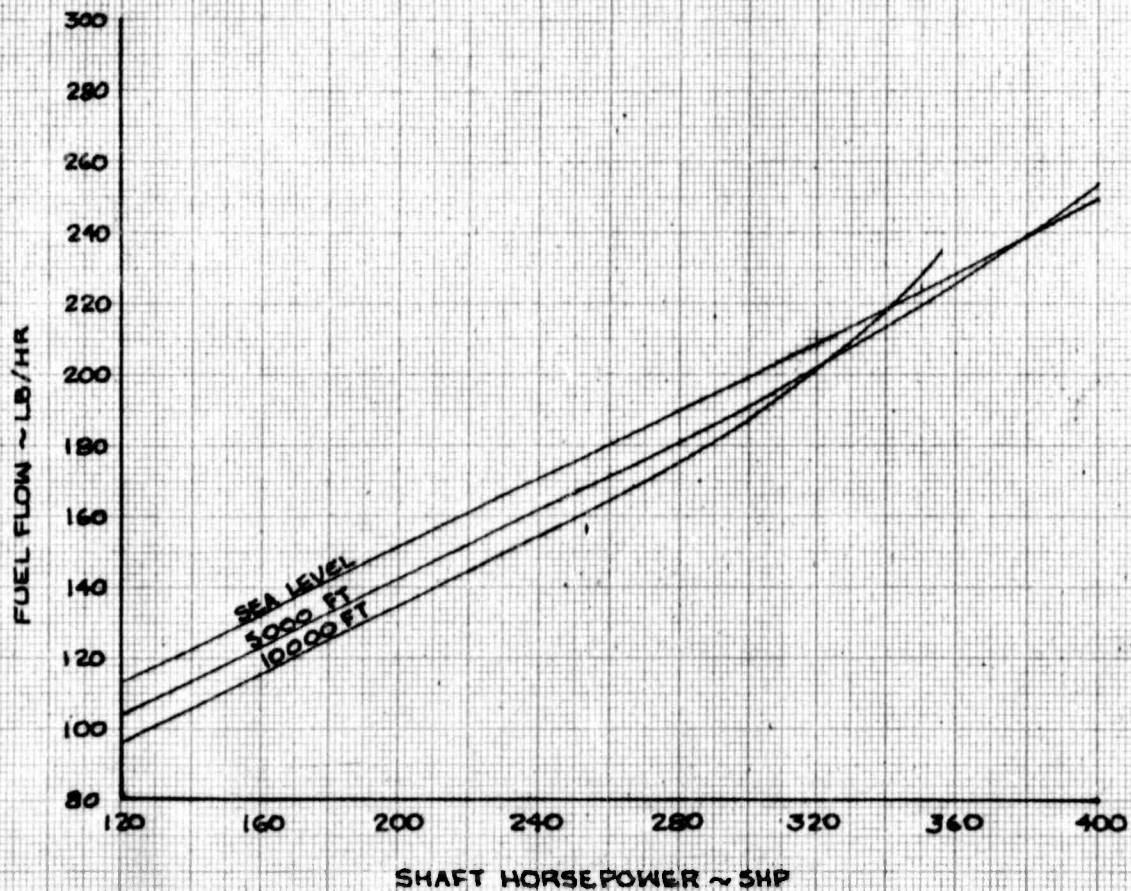
INDEX

<u>Figure</u>	<u>Figure Number</u>
Engine Performance	1 through 4
Hovering Performance	5 through 7
Level Flight Performance	8 through 15
Autorotational Descent Performance	16 through 17
Trim Control Position Characteristics	18 through 21
Critical Azimuth Determination	22
Static Longitudinal Stability	23
Static Lateral-Directional Stability	24 through 28
Dynamic Stability	29 through 31
Longitudinal Controllability	32 and 33
Lateral Controllability	34 and 35
Directional Controllability	36 and 37
Maneuvering Stability	38
Autorotational Entry	39 and 40
Airspeed Calibration	41

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FIGURE 1
SPECIFICATION FUEL FLOW
250-C20 ENGINE

NOTES: 1. SUPPLIED BY AIRFRAME MANUFACTURER
2. STANDARD DAY
3. UNINSTALLED
4. N_2 105%

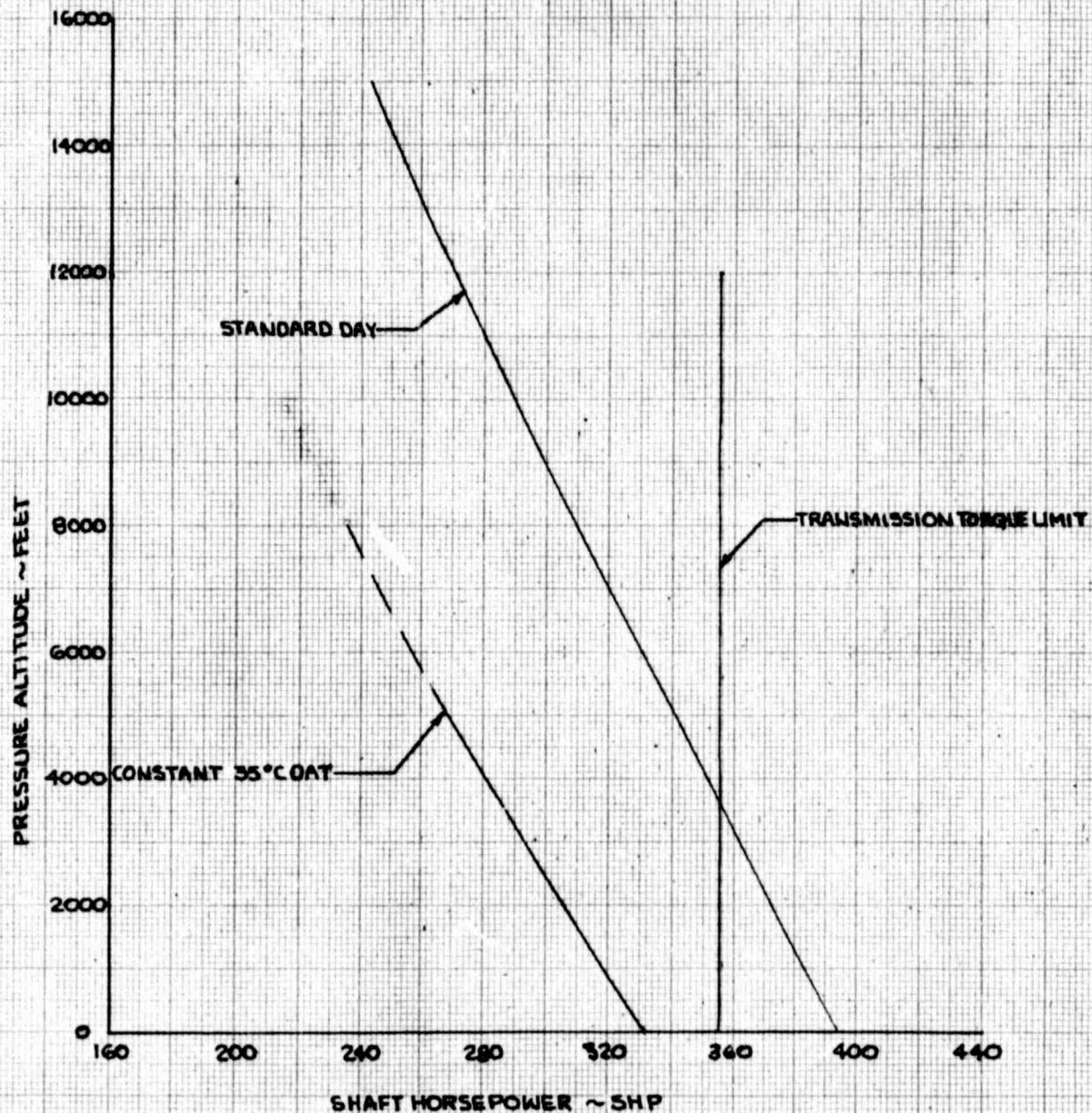


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FIGURE 2
ENGINE SHAFT HORSEPOWER AVAILABLE
IN GROUND EFFECT
TAKE-OFF POWER
250-C20 ENGINE

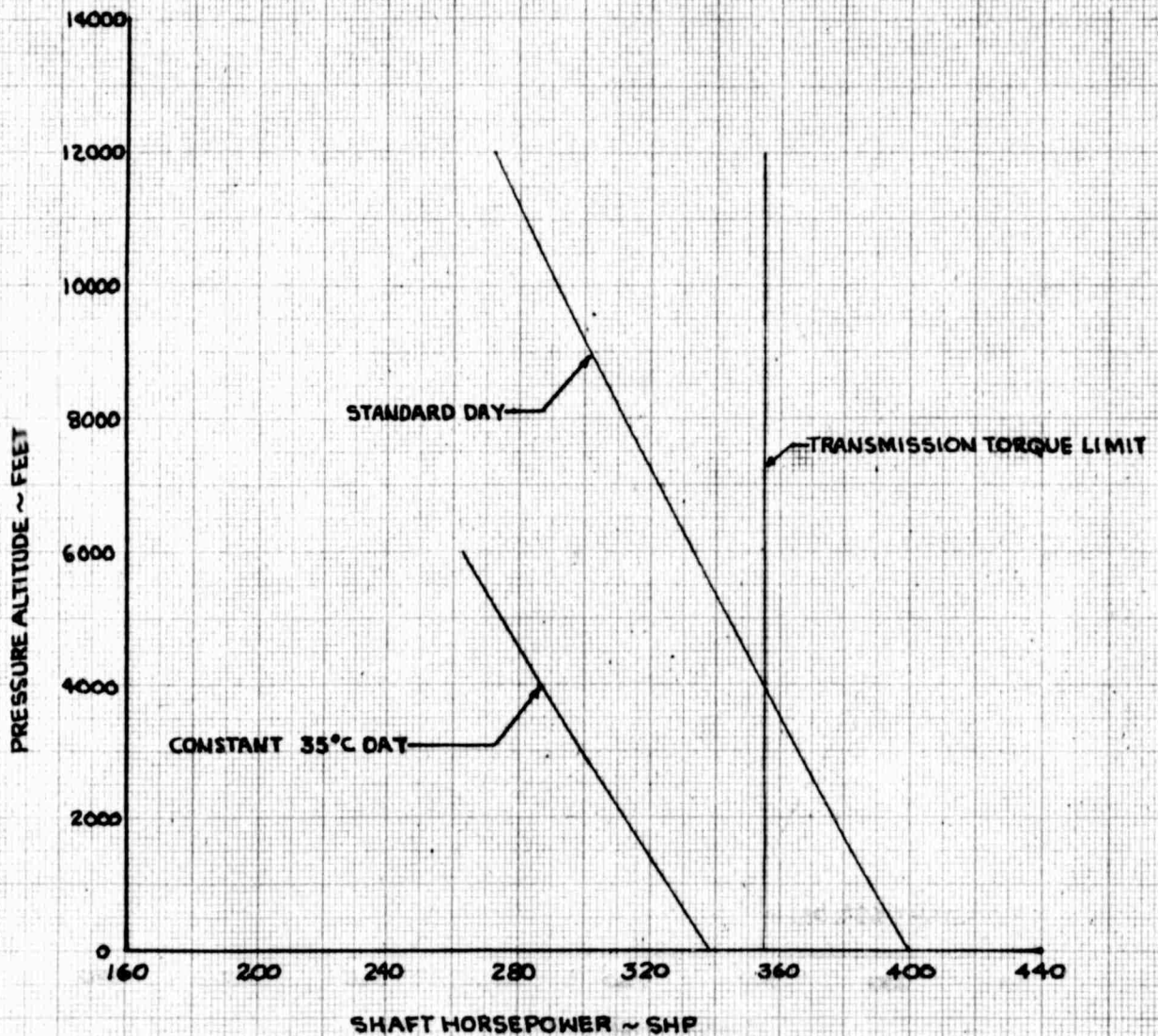
- NOTES: 1. ALL DATA SUPPLIED BY AIRFRAME MANUFACTURER
2. $N_2 = 103\%$
3. INLET PRESSURE LOSS = 22 IN. OF H_2O
4. TEMPERATURE RISE = $2.0^\circ C$
5. EXHAUST PRESSURE = STD ATM PRESSURE
+ 0.65 IN. OF Hg
6. BROKEN LINE DENOTES EXTRAPOLATION



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FIGURE 3
ENGINE SHAFT HORSEPOWER AVAILABLE
OUT OF GROUND EFFECT
TAKE-OFF POWER
250-C 20 ENGINE

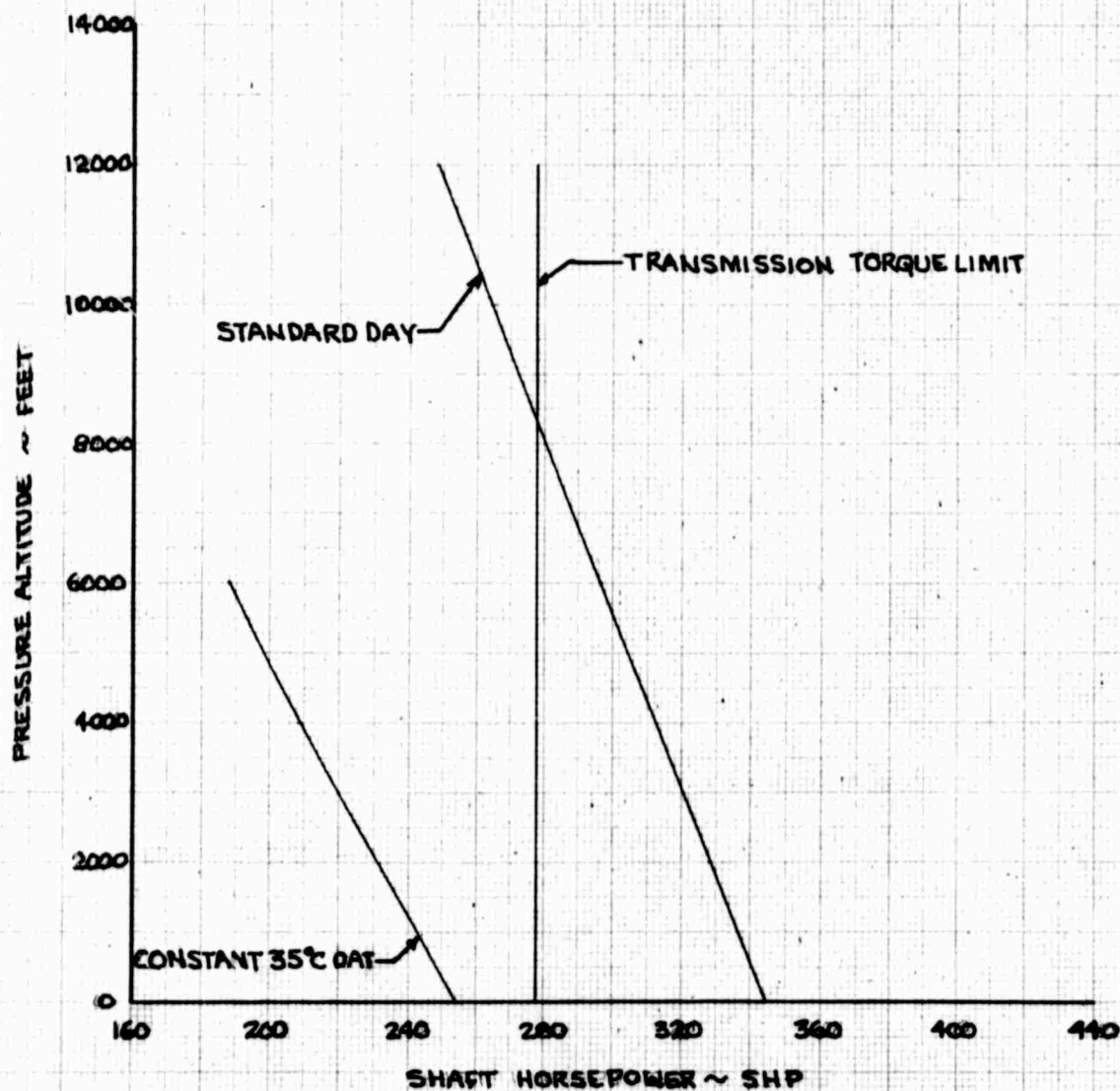
- NOTES: 1. ALL DATA SUPPLIED BY AIRFRAME MANUFACTURER
2. $N_2 = 103\%$
3. INLET PRESSURE LOSS = 2.2 IN. OF H_2O
4. EXHAUST PRESSURE = STD ATM PRESSURE
+ 0.65 IN. OF Hg



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FIGURE 4
ENGINE SHAFT HORSEPOWER AVAILABLE
OUT OF GROUND EFFECT
CONTINUOUS POWER
250-C20 ENGINE

NOTES: 1. ALL DATA SUPPLIED BY AIRFRAME MANUFACTURER
2. $N_2 = 103\%$
3. INLET PRESSURE LOSS = 2.2 IN. OF H_2O
4. EXHAUST PRESSURE = STD ATM PRESSURE
+ 0.65 IN. OF Hg



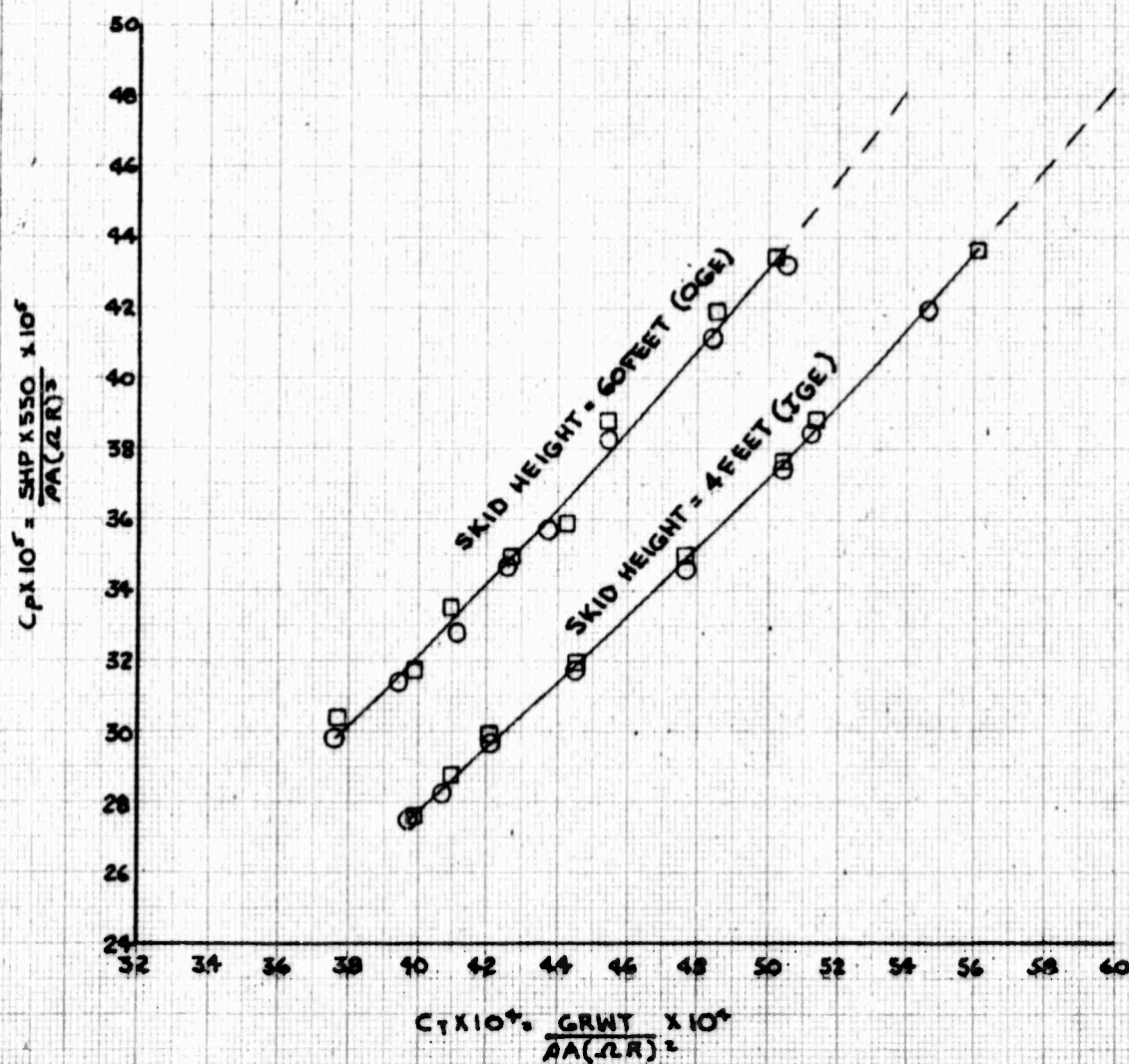
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~~FOR OFFICIAL USE ONLY~~

FIGURE 5
NON-DIMENSIONAL HOVERING PERFORMANCE
369C 4/N 65-12981

- NOTES: 1. TETHERED HOVERING METHOD
 2. WIND LESS THAN 2 KNOTS
 3. DENSITY ALTITUDE - 600 FT
 4. OAT = 19.5°C
 5. HEIGHT FROM BOTTOM OF SKID TO ROTOR HUB = 8.46 FT

○ ~ 510 RPM
 □ ~ 505 RPM

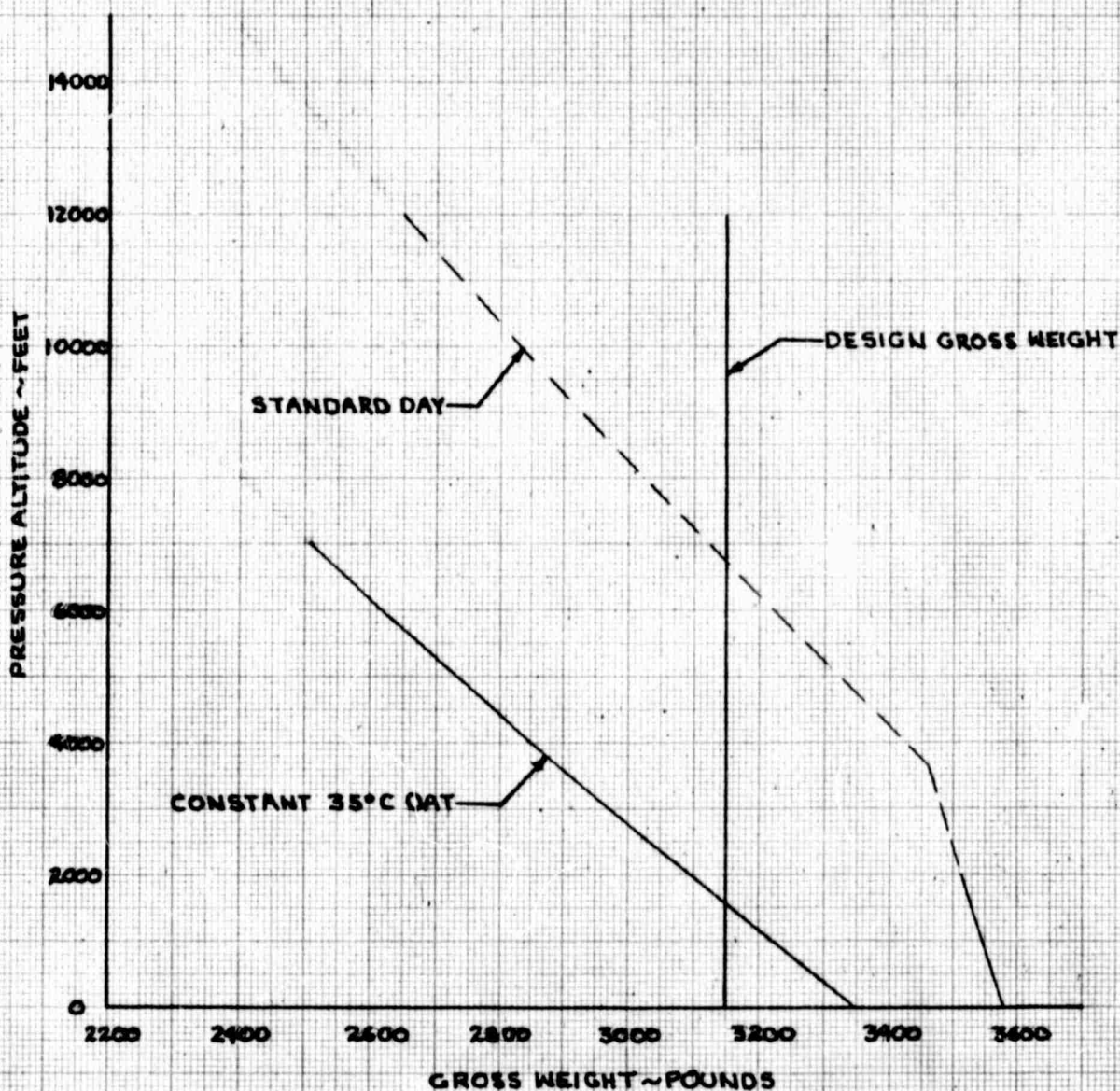


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FIGURE 6
IN GROUND EFFECT HOVERING LIFTING
369C 4/65-12951

4 FOOT SKID HEIGHT
TAKE-OFF POWER

- NOTES: 1. SHP OBTAINED FROM FIG. 2
2. CURVES DERIVED FROM FIG. 5
3. BROKEN LINE DERIVED FROM
EXTRAPOLATED PORTION OF FIG. 5
4. ROTOR SPEED = 510 RPM ($N_2 = 103\%$)
5. WIND LESS THAN 2 KNOTS
6. HEIGHT FROM BOTTOM OF SKID
TO ROTOR HUB = 8.46 FT

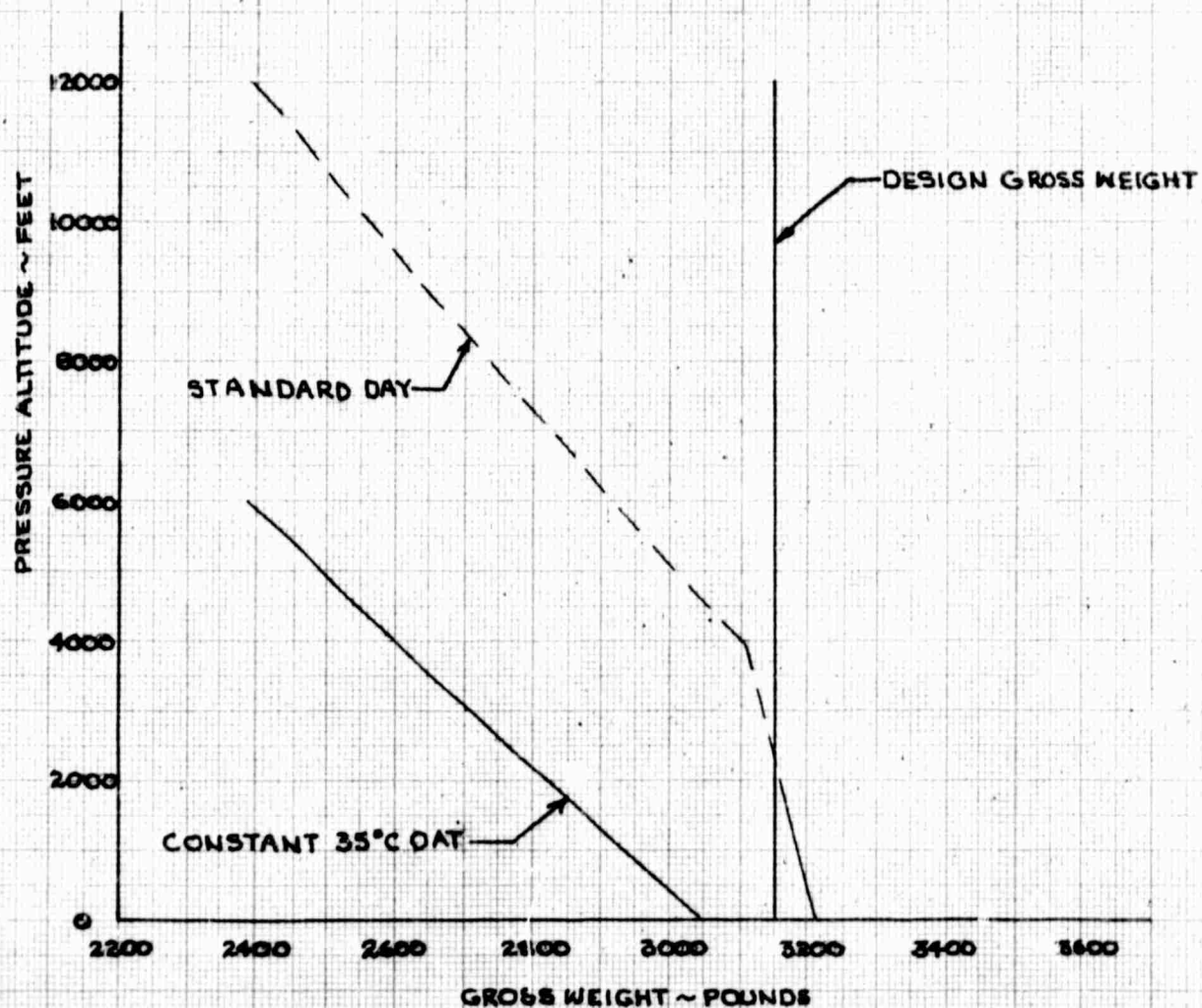


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FIGURE 7
OUT OF GROUND EFFECT HOVERING CEILING
369C
TAKE-OFF POWER
5N65-12951

- NOTES :
1. SHP OBTAINED FROM FIG. 3
 2. CURVES DERIVED FROM FIG. 5
 3. BROKEN LINE DERIVED FROM
EXTRAPOLATED PORTION OF FIG. 5
 4. ROTOR SPEED = 510 RPM (N_2 103%)
 5. WIND LESS THAN 2 KNOTS
 6. HEIGHT FROM BOTTOM OF SKID
TO ROTOR HUB = 8.46 FT

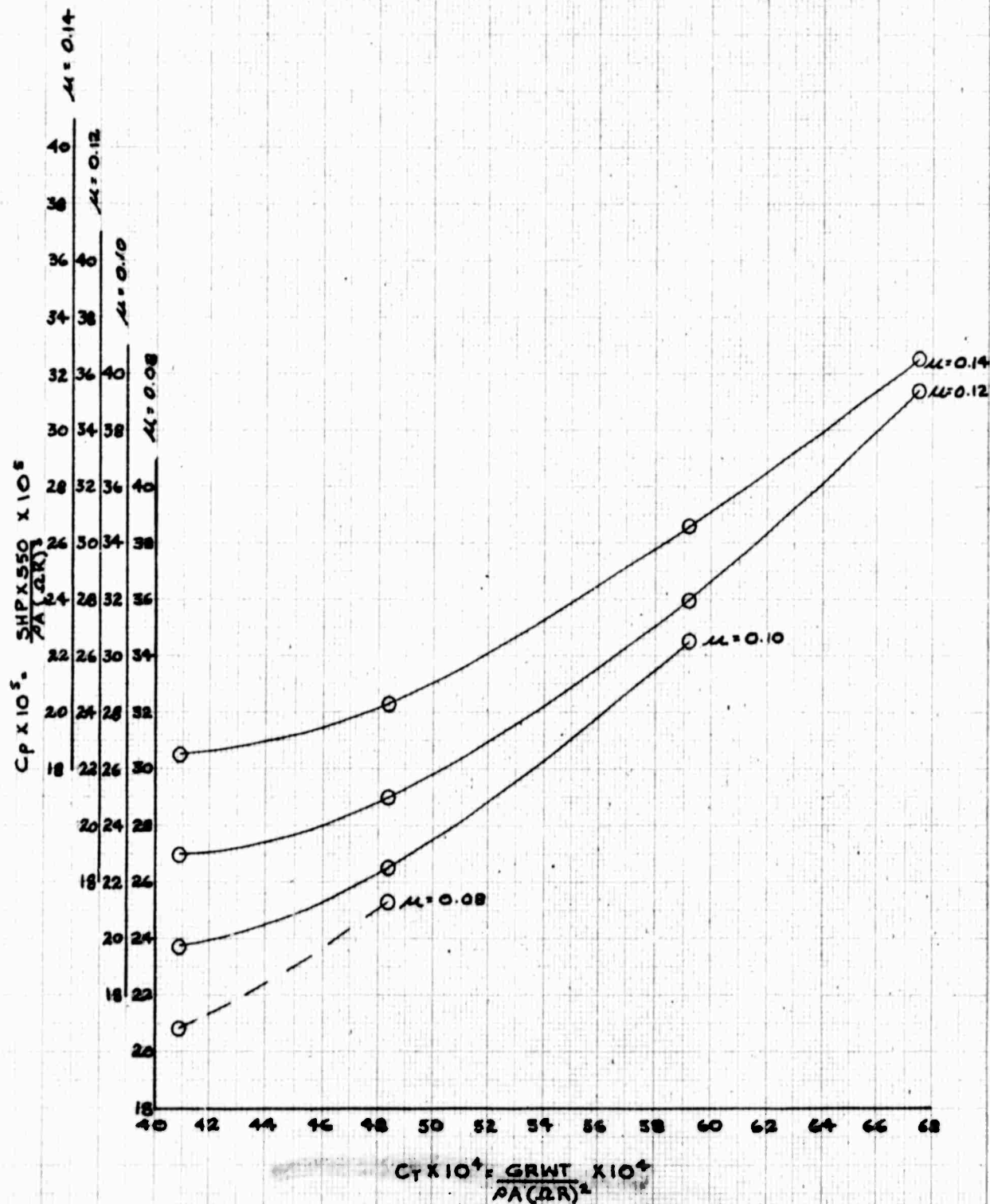


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FIGURE 8
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
369C SN65-12951

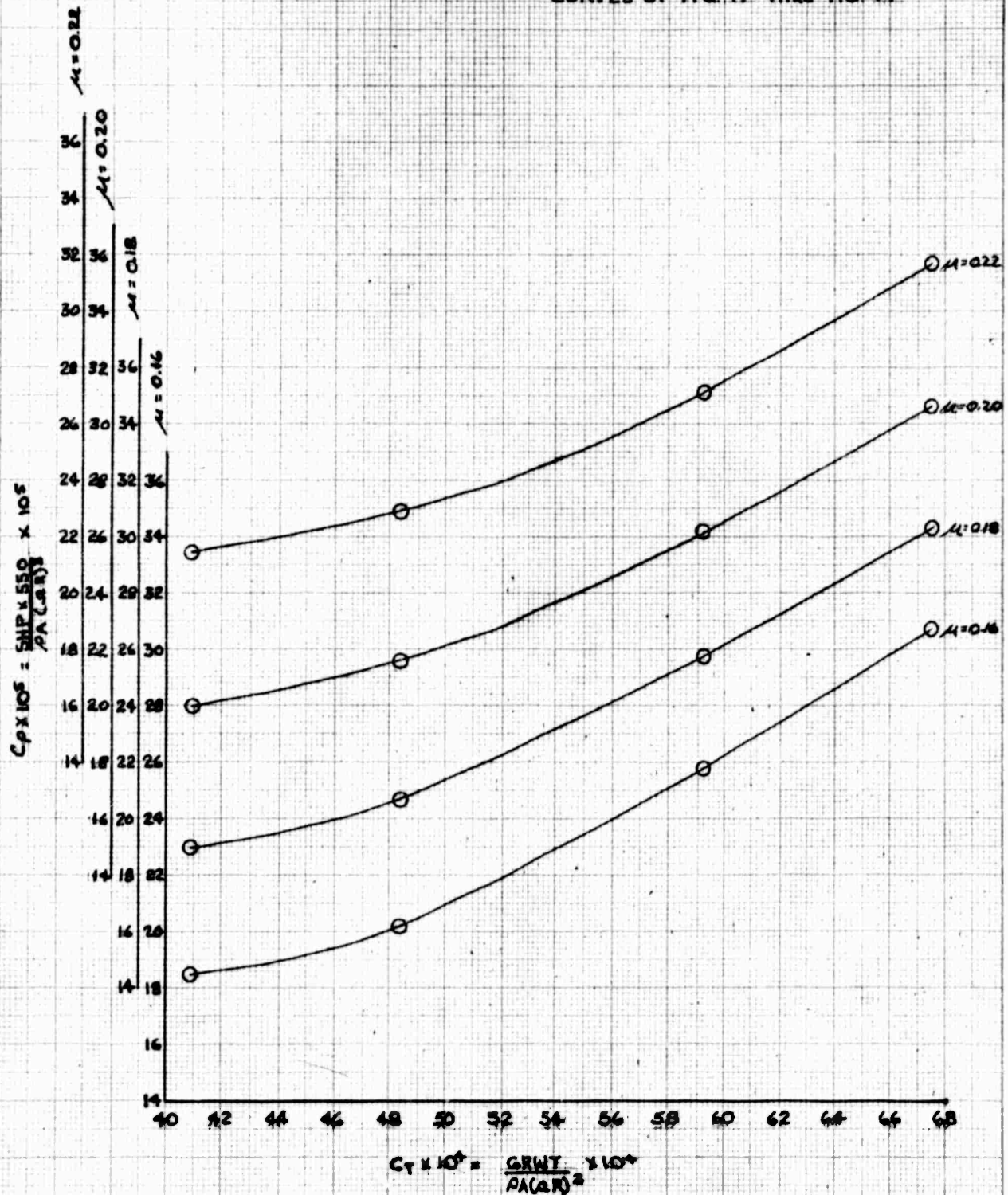
- NOTES: 1. ROTOR SPEED = 510 RPM
2. POINTS DERIVED FROM FAIRED CURVES
OF FIG. 11 THRU FIG. 14



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FIGURE 9 **NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE** **369C** **W65-12951**

NOTES: 1. ROTOR SPEED = 510RPM
 2. POINTS DERIVED FROM FAIRED
 CURVES OF FIG. 11 THRU FIG. 14



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FIGURE 10
NON-DIMENSIONAL LEVEL FLIGHT PERFORMANCE
369C 3/65-12951

NOTE 6: 1. ROTOR SPEED = 510 RPM
2. POINTS DERIVED FROM FAIRED CURVES OF FIG. 11 THRU FIG. 14

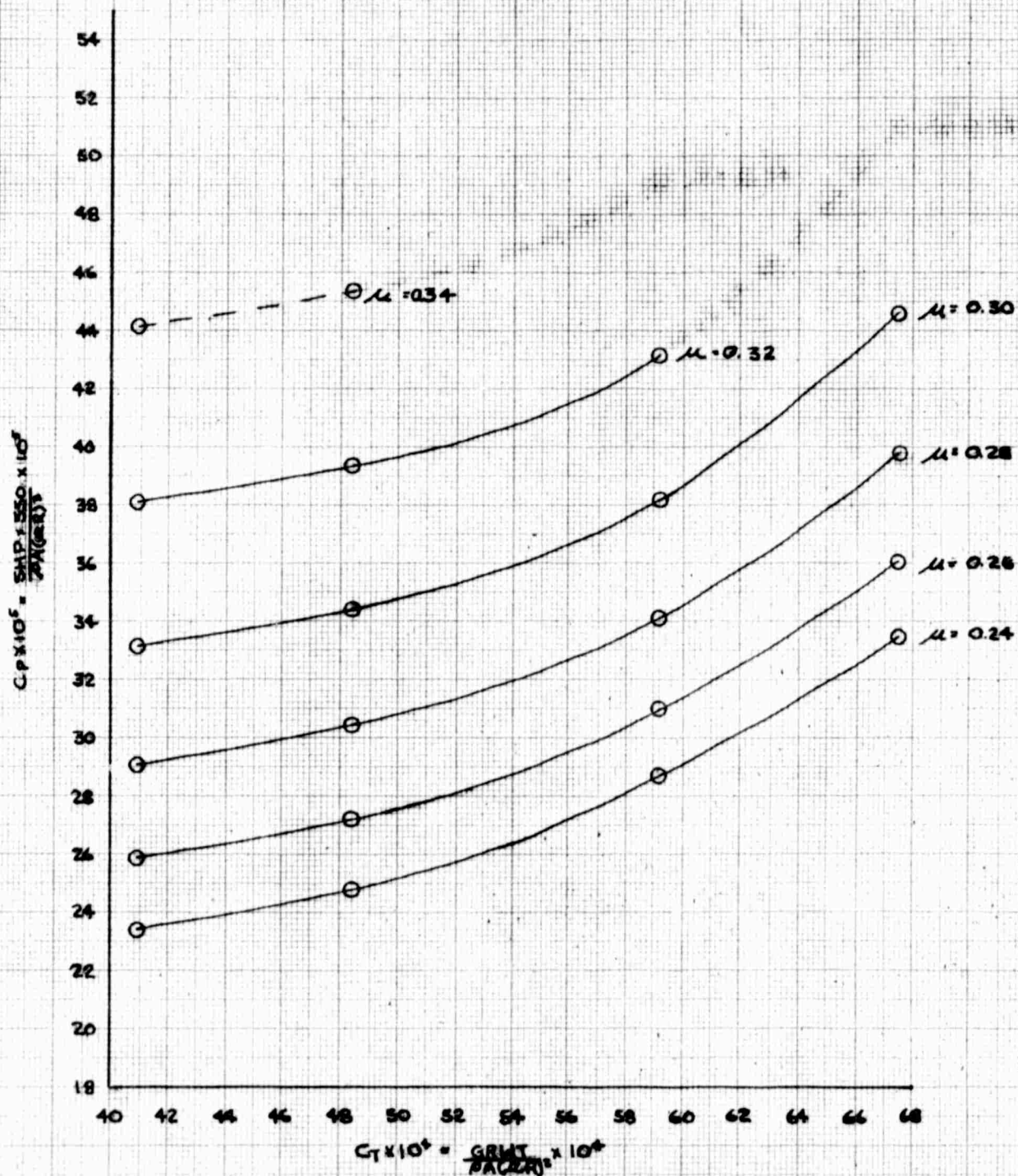


FIGURE 11
LEVEL FLIGHT PERFORMANCE
 369 C 5465-12951

<u>AVG DENSITY</u> <u>ALTITUDE ~ FT</u>	<u>AVG</u> <u>GRWT ~ LB</u>	<u>AVG</u> <u>OAT ~ °C</u>	<u>AVG LONG.</u> <u>C G ~ IN.</u>	<u>AVG ROTOR</u> <u>SPEED ~ RPM</u>	<u>AVG</u> <u>C_T</u>
3100	2420	25.5	101.1 (MID)	510	0.004088

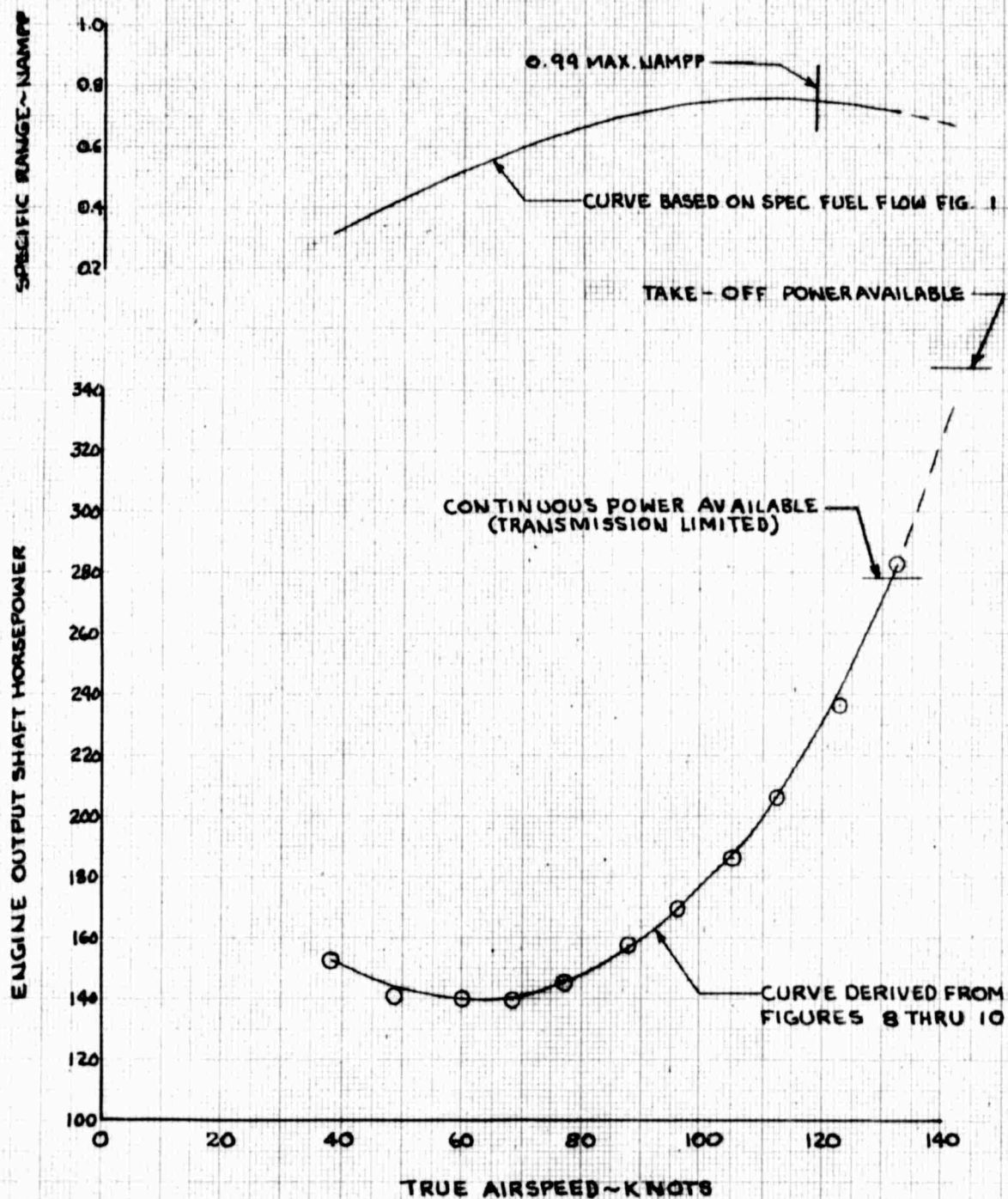


FIGURE 12 **LEVEL FLIGHT PERFORMANCE**

3690

465-12951

AUG DENSITY
ALTITUDE ~ FT
2290

AUG
GRWT ~ LB
2930

AUG
OAT ~ °C
24.5

AUG LONG
CG ~ IN.
104.1 (AFT)

AUG ROTOR
SPEED ~ RPM
510

AUG
Ct
0.004838

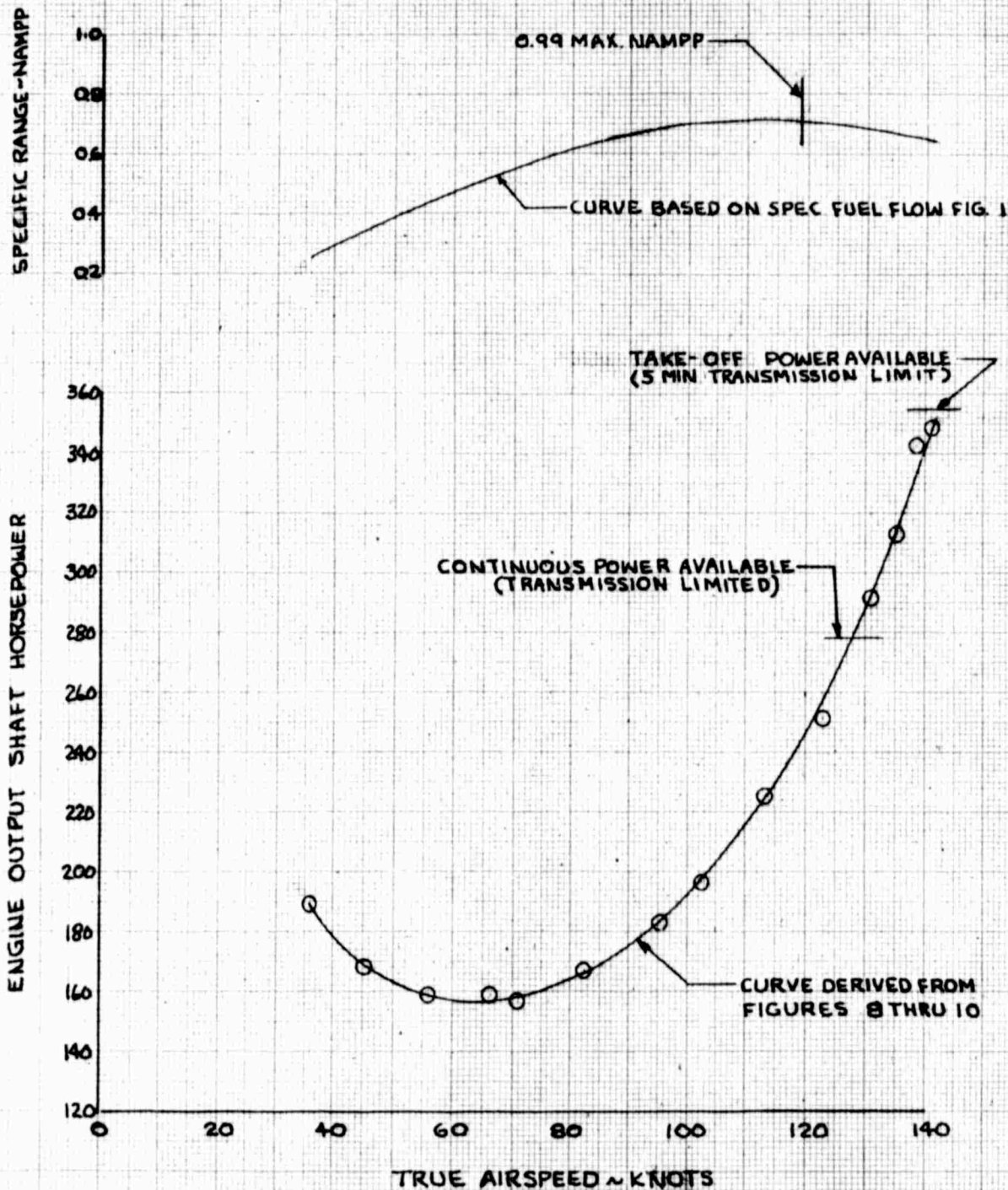


FIGURE 13
LEVEL FLIGHT PERFORMANCE
 369C 7/65-12951

<u>AVG DENSITY</u> <u>ALTITUDE~FT</u>	<u>AVG</u> <u>GRWT~LB</u>	<u>AVG</u> <u>OAT~°C</u>	<u>AVG LONG.</u> <u>CG ~IN.</u>	<u>AVG ROTOR</u> <u>SPEED~RPM</u>	<u>AVG</u> <u>C_T</u>
7190	3090	24.0	101.0(MID)	510	0.005920

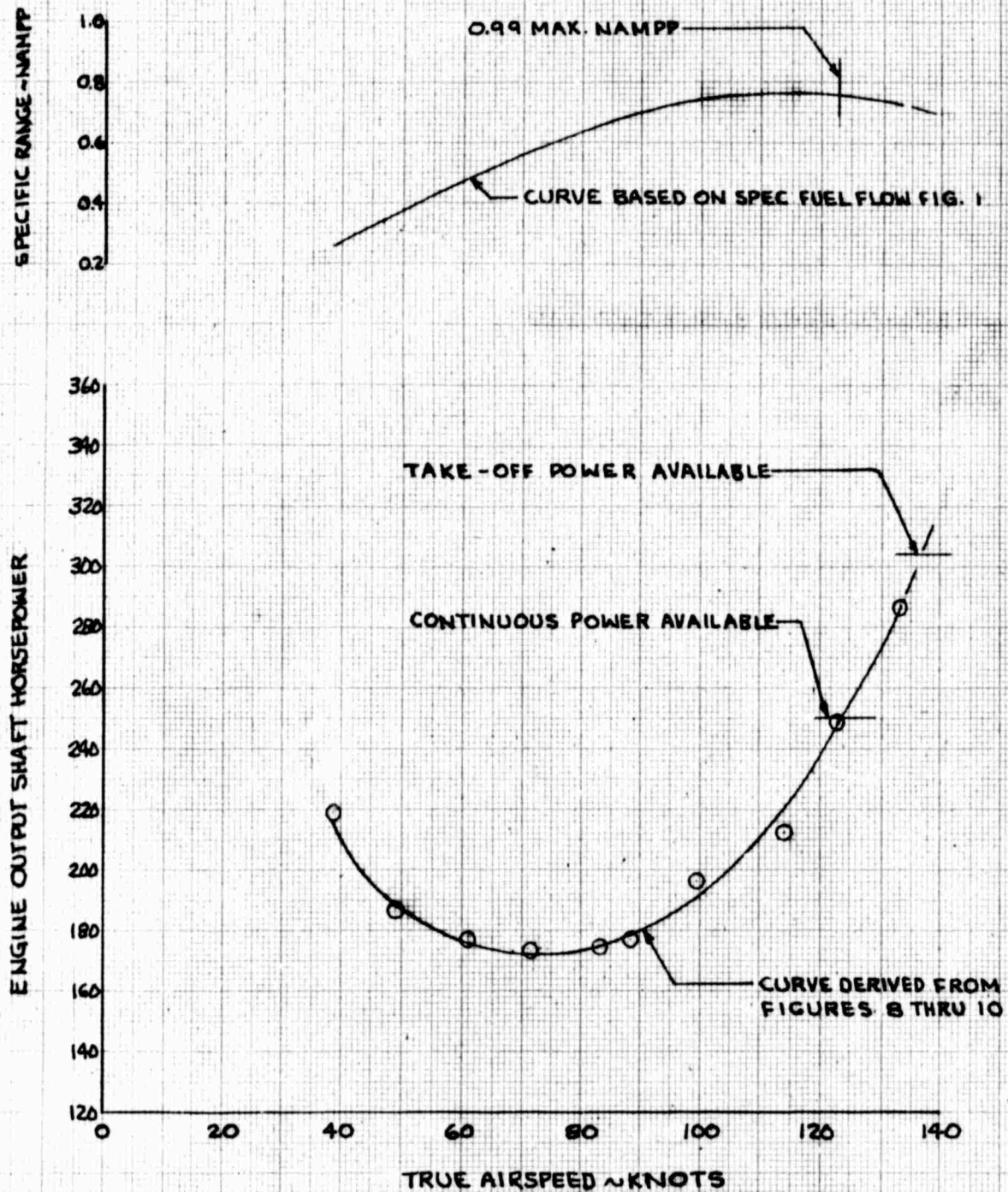


FIGURE 14
LEVEL FLIGHT PERFORMANCE
 369C 5465-12951

<u>AVG DENSITY</u> <u>ALTITUDE~FT</u>	<u>AVG</u> <u>GRWT~LB</u>	<u>AVG</u> <u>OAT~°C</u>	<u>AVG LONG</u> <u>C G ~ IN.</u>	<u>AVG ROTOR</u> <u>SPEED~RPM</u>	<u>AVG</u> <u>Ct</u>
11540	3070	18.5	101.0(MID)	510	0.006752

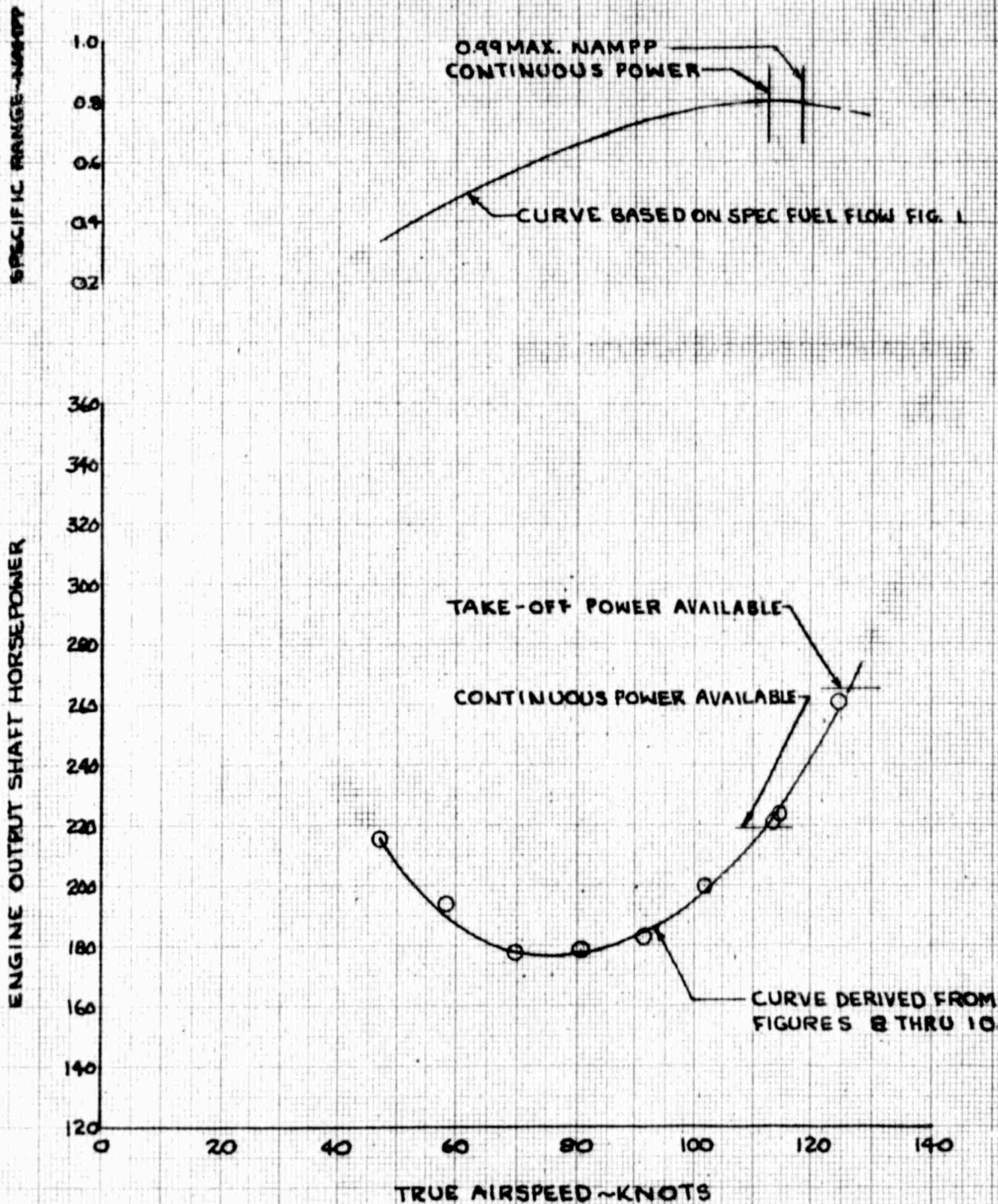


FIGURE 15
LEVEL FLIGHT RANGE PERFORMANCE
369C **465-12951**

NOTES: 1. STANDARD DAY

2. ROTOR SPEED = 510 RPM

3. CURVES DERIVED FROM FIG. 8 THROUGH FIG. 10
 AND FIG. 1

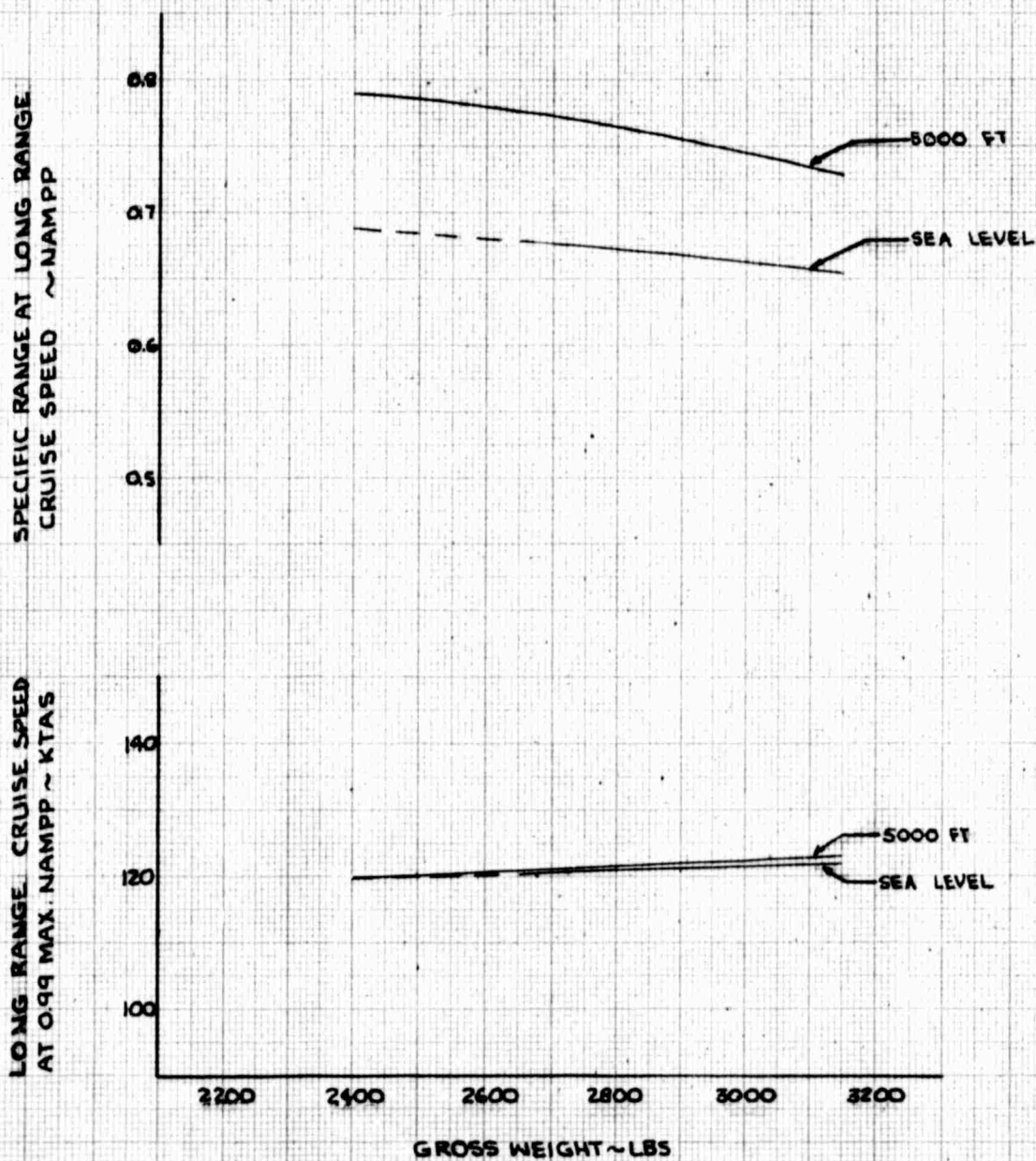


FIGURE 16
AUTOROTATIONAL DESCENT PERFORMANCE
369C SN65-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG CG ~IN.	ROTOR SPEED ~RPM	AVG CT
1900	8050	18.0	104.0(AFF)	510	0.004960

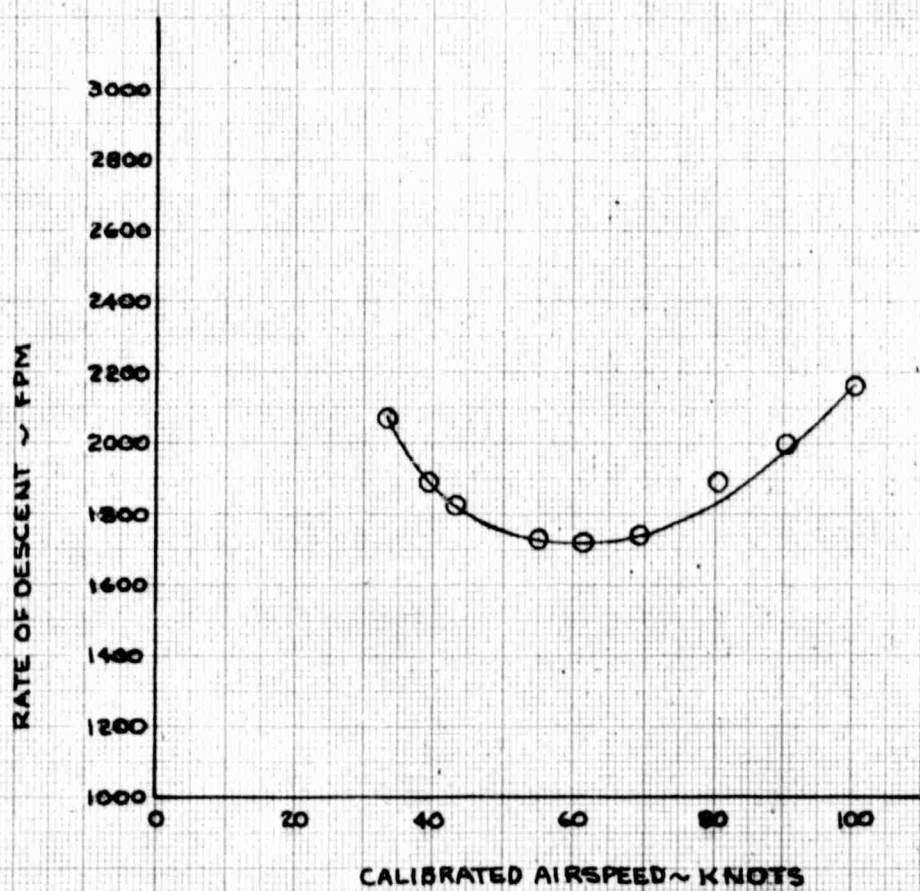
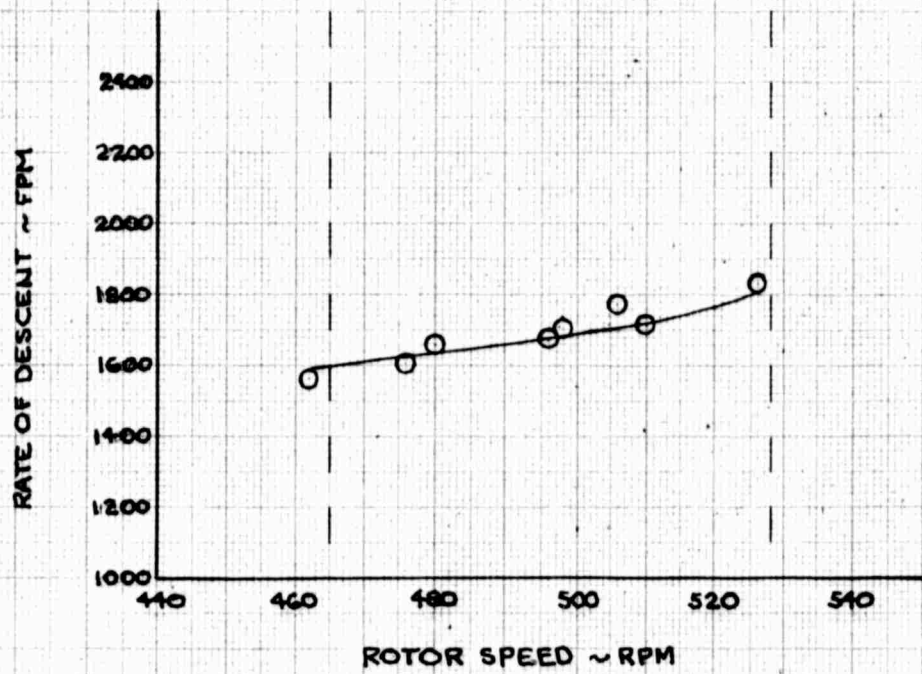


FIGURE 17
AUTOROTATIONAL DESCENT PERFORMANCE
369C 5465-12951

AVG DENSITY ALTITUDE ~ FT	AVG GRWT ~ LB	AVG OAT ~ °C	AVG LONG. CG ~ IN.	AVG TRIM AIRSPEED ~ KCAS
2240	3100	21.0	104.1 (AFT)	60

NOTE: BROKEN LINES DENOTE STEADY STATE
AUTOROTATIONAL ROTOR SPEED LIMITS

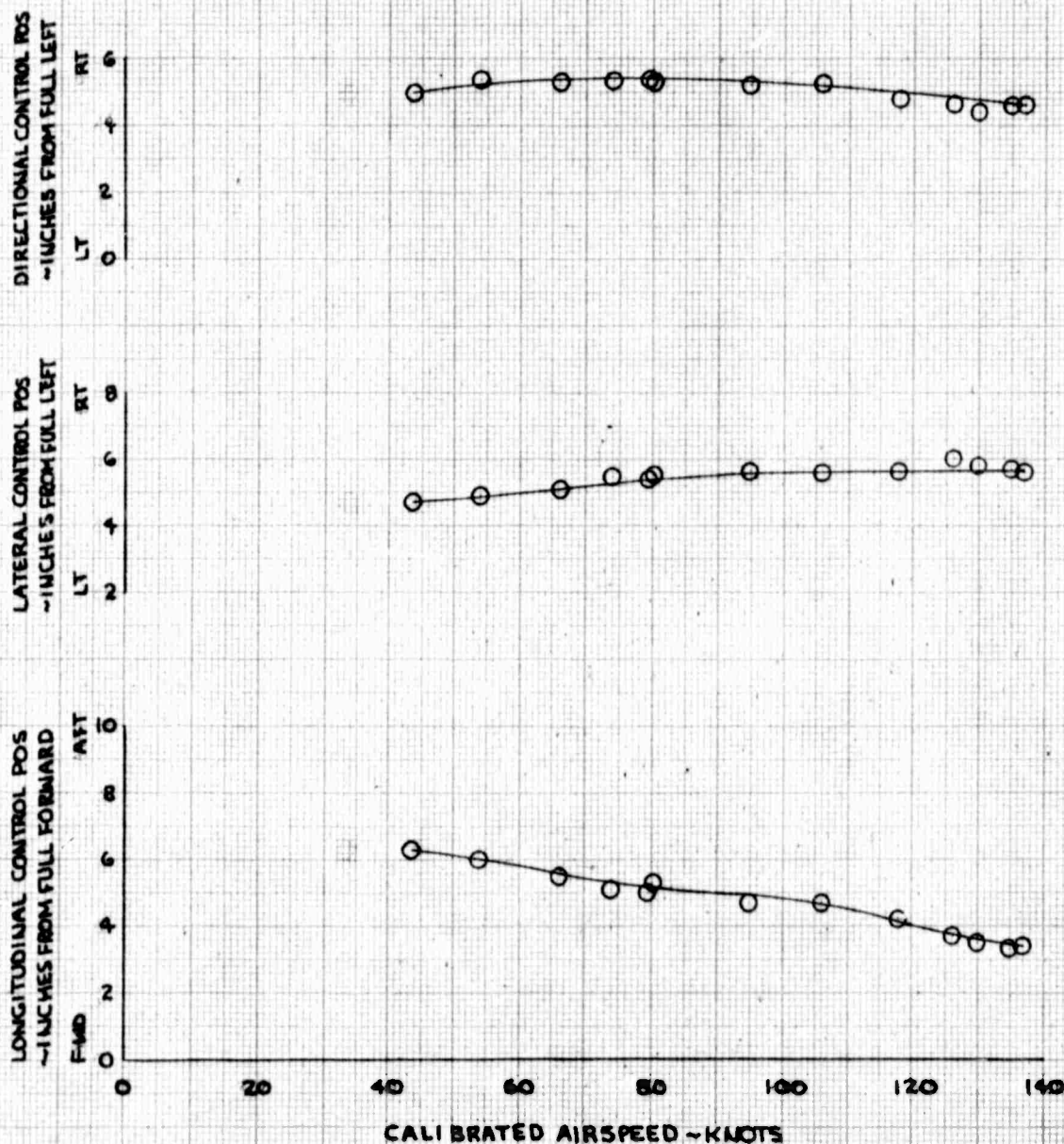


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FIGURE 18
TRIM CONTROL POSITIONS IN LEVEL FLIGHT
369C 5465-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG CG ~IN.	ROTOR SPEED ~RPM	AVG CT
2380	3100	30.0	104.0(AFT)	510	0.005134

NOTE: TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES



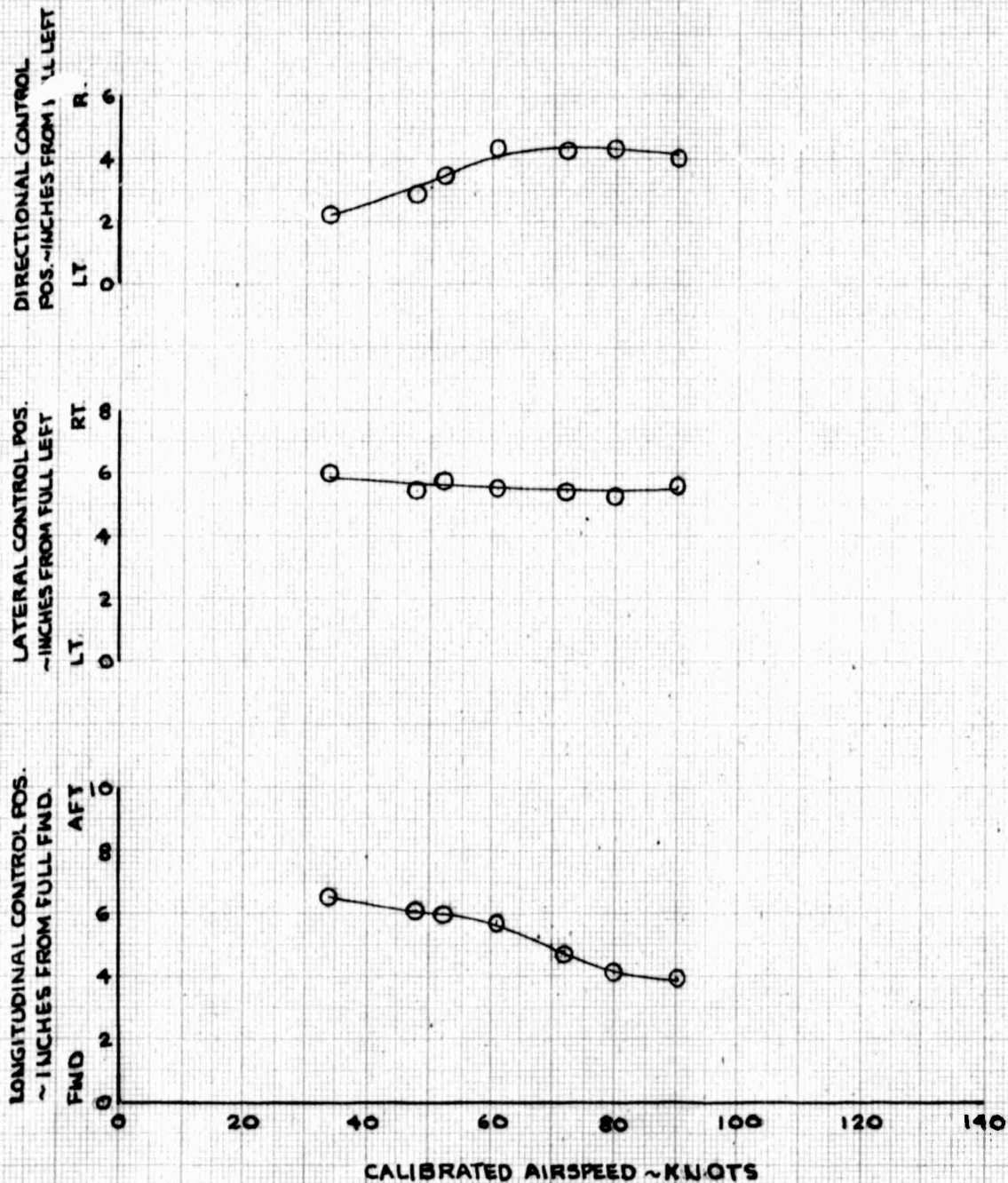
59
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FIGURE 19
 TRIM CONTROL POSITIONS IN MAXIMUM POWER CLIMBS
 369C 3465-12951

AVG DENSITY ALTITUDE ~ FT 1900	AVG GRWT ~ LB 3050	AVG OAT ~ °C 18.0	AVG LONG. CG ~ IN. 104.0(AFT)	ROTOR SPEED ~ RPM 310	AVG CT 0.004980
---	-----------------------------	----------------------------	--	--------------------------------	-----------------------

NOTE: TOTAL CONTROL DISPLACEMENT
 LONGITUDINAL = 12.55 INCHES
 LATERAL = 11.55 INCHES
 DIRECTIONAL = 7.60 INCHES



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FIGURE 20
TRIM CONTROL POSITIONS IN SIDEWARD FLIGHT
 369C 3465-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG. CG ~IN.	ROTOR SPEED ~RPM	AVG CT
860	3120	20.5	96.9(FWD)	510	0.004440

NOTE: TOTAL CONTROL DISPLACEMENT
 LONGITUDINAL = 12.35 INCHES
 LATERAL = 11.55 INCHES
 DIRECTIONAL = 7.60 INCHES

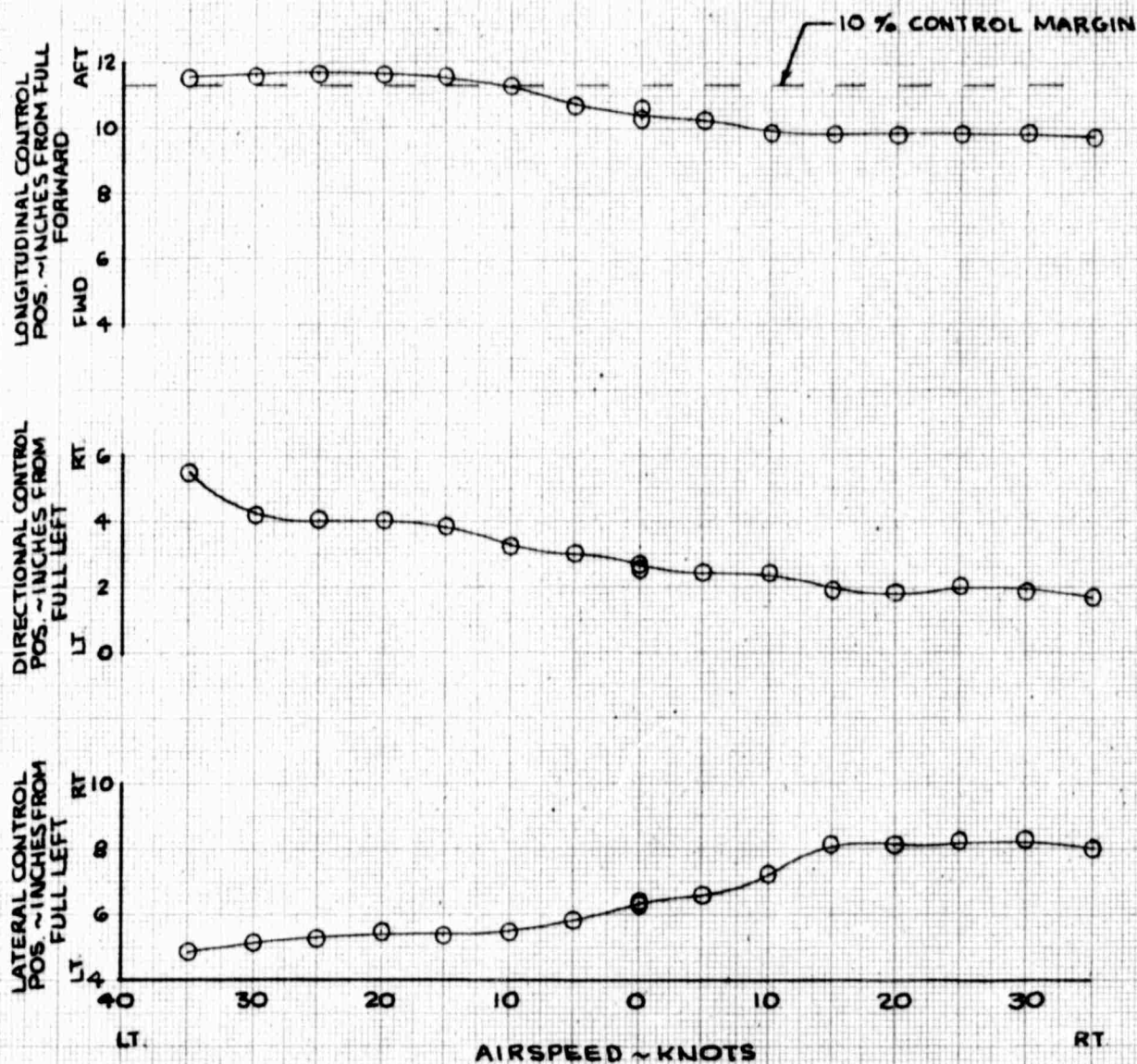
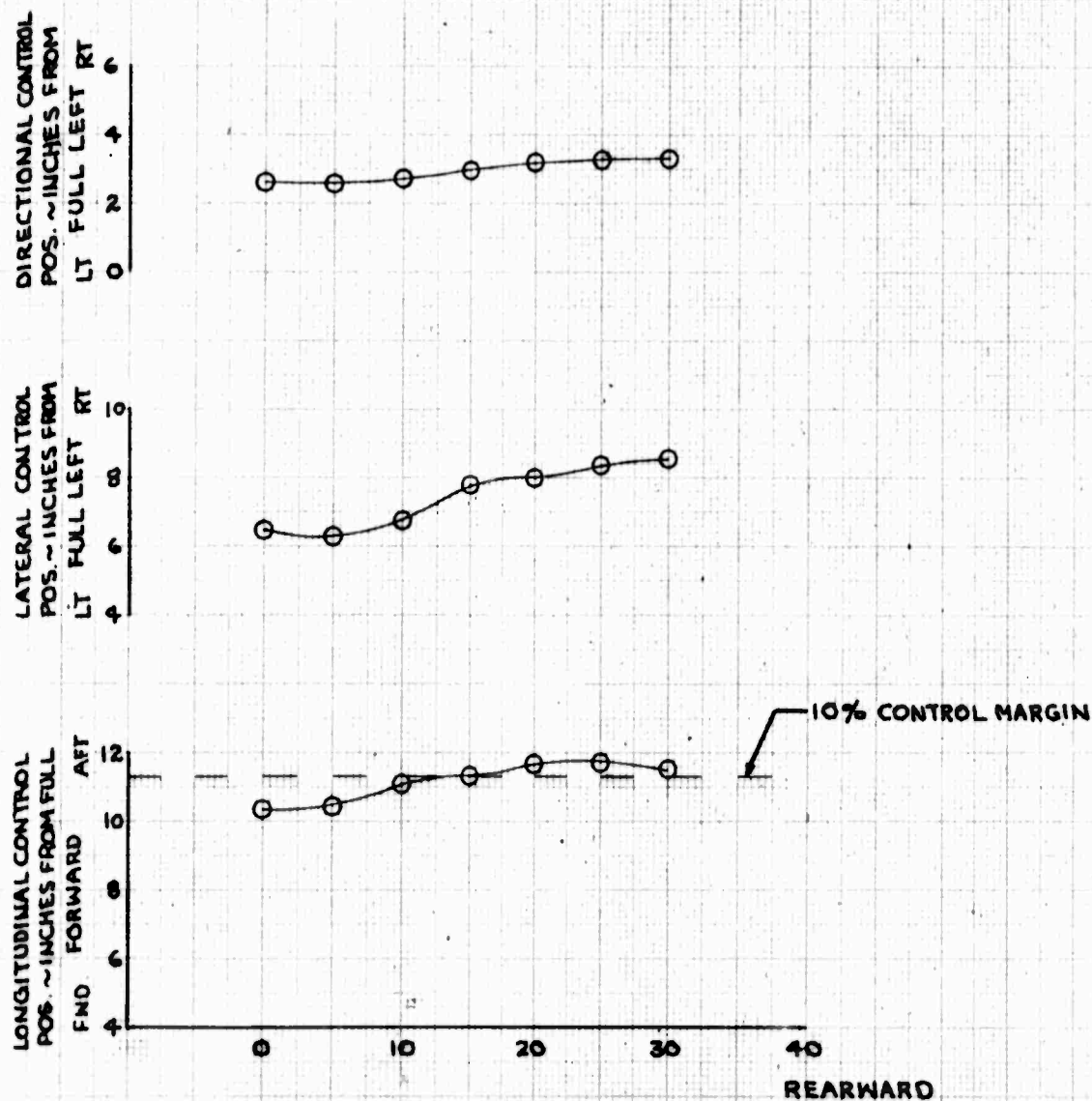


FIGURE 21

TRIM CONTROL POSITIONS IN REARWARD FLIGHT
369C 8/N65-12951

AVG DENSITY ALTITUDE ~ FT	AVG GRNT ~ LB	AVG OAT ~ °C	AVG LONG CG ~ IN.	ROTOR SPEED ~ RPM	AVG CT
900	3160	21.0	96.9(FWD)	510	0.005009

NOTE : TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES



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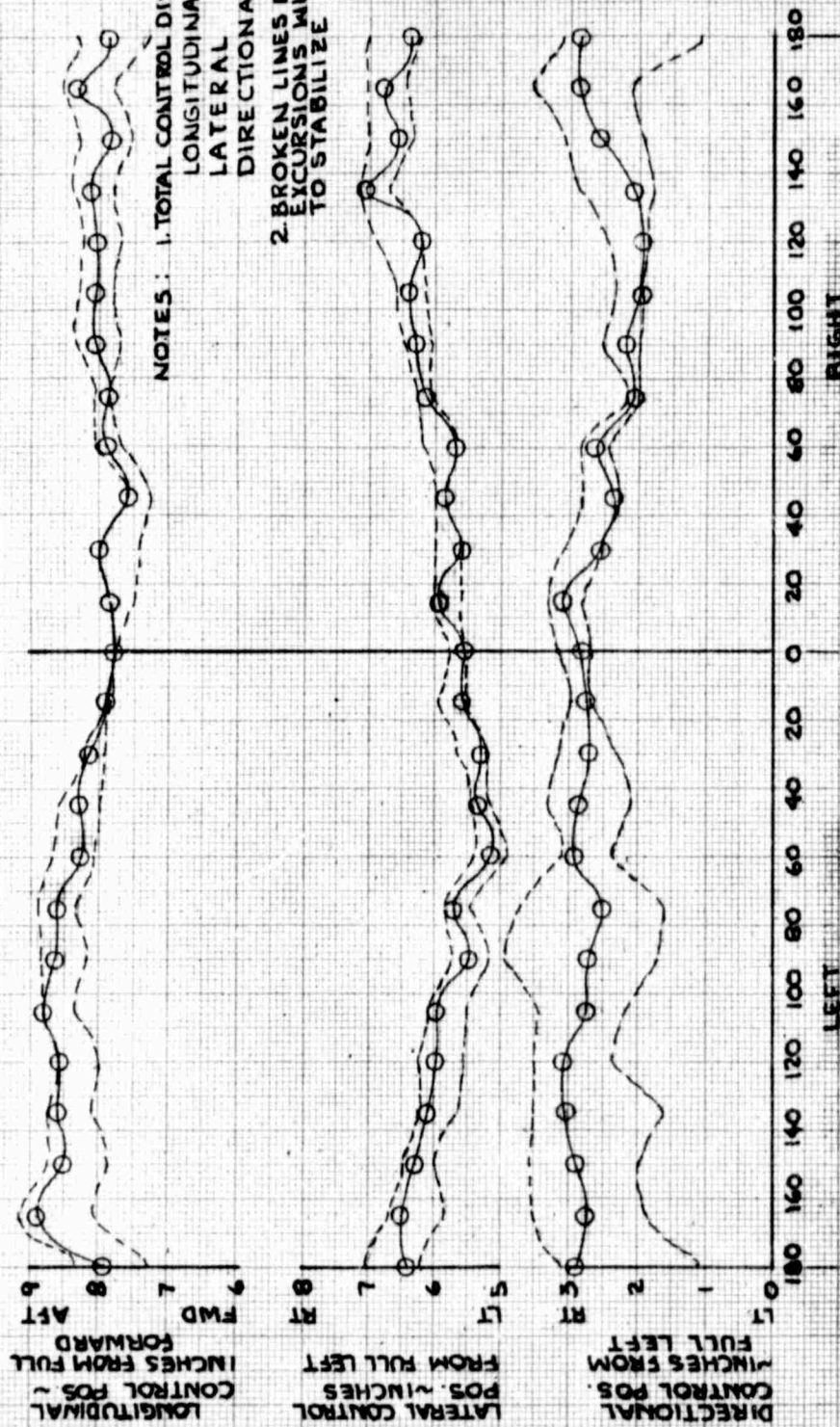
FIGURE 22

CRITICAL AZIMUTH DETERMINATION

5/16.5-12951

APPROXIMATE 3 FOOT SKID HEIGHT (JGE)

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG. CG ~IN.	ROTOR SPEED ~RPM	AVG CT	WIND VELOCITY ~KTS
980	3160	22.5	103.9 (AFT)	510	0.005021	10-16



NOTES: 1. TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES

2. BROKEN LINES DENOTE CONTROL EXCURSIONS WHILE ATTEMPTING TO STABILIZE

WIND AZIMUTH ~ DEGREES FROM NOSE OF AIRCRAFT

RIGHT

LEFT

FIGURE 23 **STATIC LONGITUDINAL COLLECTIVE FIXED STABILITY** **369C** **3465-12981**

SYMBOL	AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG QAT ~°C	AVG LONG CG ~IN.	ROTOR SPEED ~RPM	AVG Ct	TRIM AIRSPEED ~KIAS	FLT COND
△	2340	3080	24.0	104.1(AFT)	510	0.005092	55	LEVEL
▽	2490	3120	25.0	104.1(AFT)	510	0.005184	108	LEVEL
□	2300	3120	26.0	104.1(AFT)	510	0.005155	137	LEVEL

NOTES: 1. SHADED SYMBOLS DENOTE TRIM POINT
2. TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES

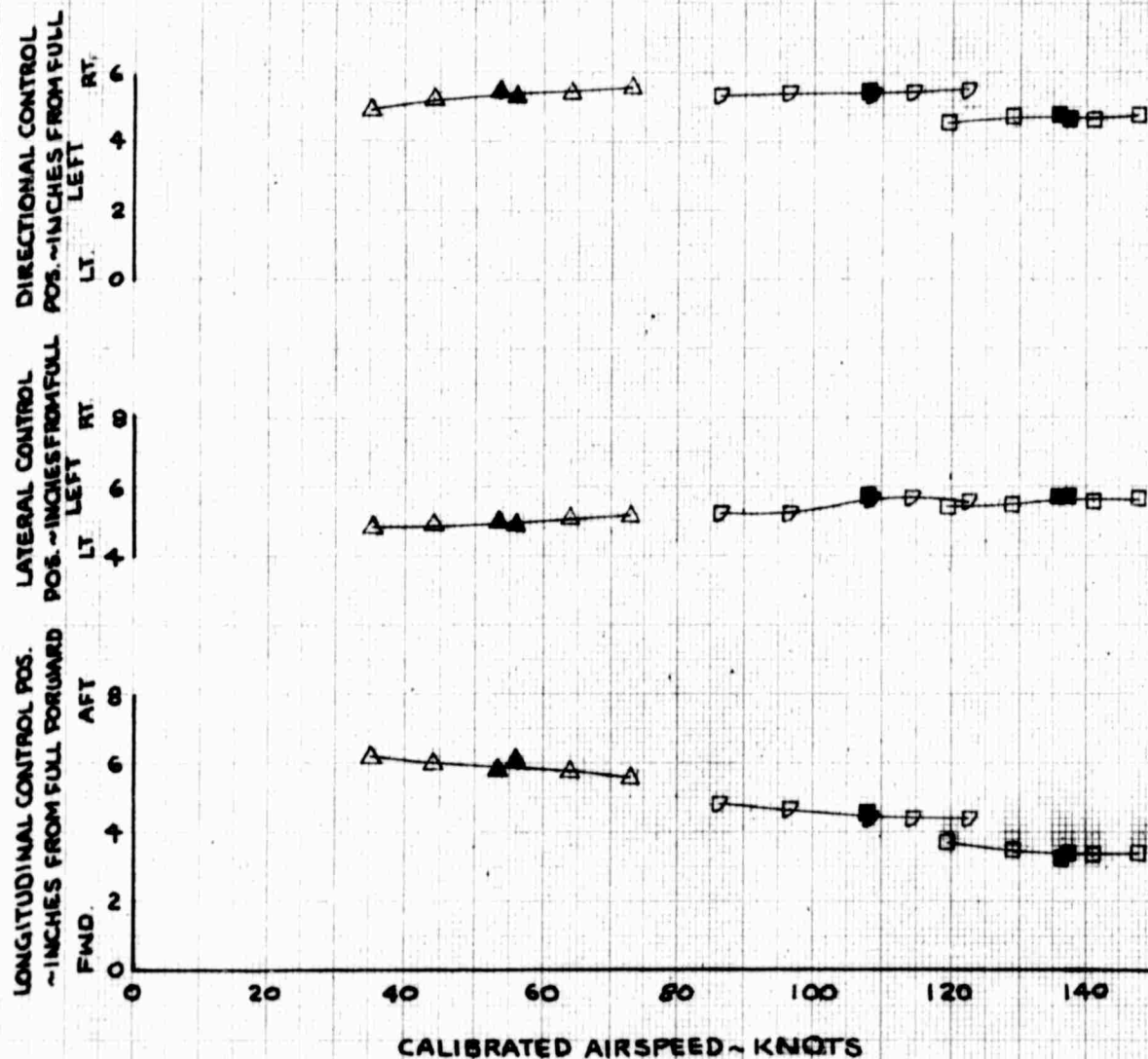


FIGURE 24
STATIC LATERAL-DIRECTIONAL STABILITY
 369C 9465-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG CG ~IN.	ROTOR SPEED ~RPM	AVG CT 0.005108	TRIM AIRSPEED ~KNOTS	FLY COND
2320	3090	23.5	104.1(AFT)	510		55	LEVEL

- NOTES:
1. COLLECTIVE CONTROL POSITION HELD FIXED DURING TEST
 2. SHADED SYMBOLS DENOTE TRIM POINT
 3. TOTAL CONTROL DISPLACEMENT
 LONGITUDINAL = 12.55 INCHES
 LATERAL = 11.55 INCHES
 DIRECTIONAL = 7.60 INCHES
 4. BROKEN LINES DENOTE LEVEL FLIGHT SIDE SLIP LIMITS

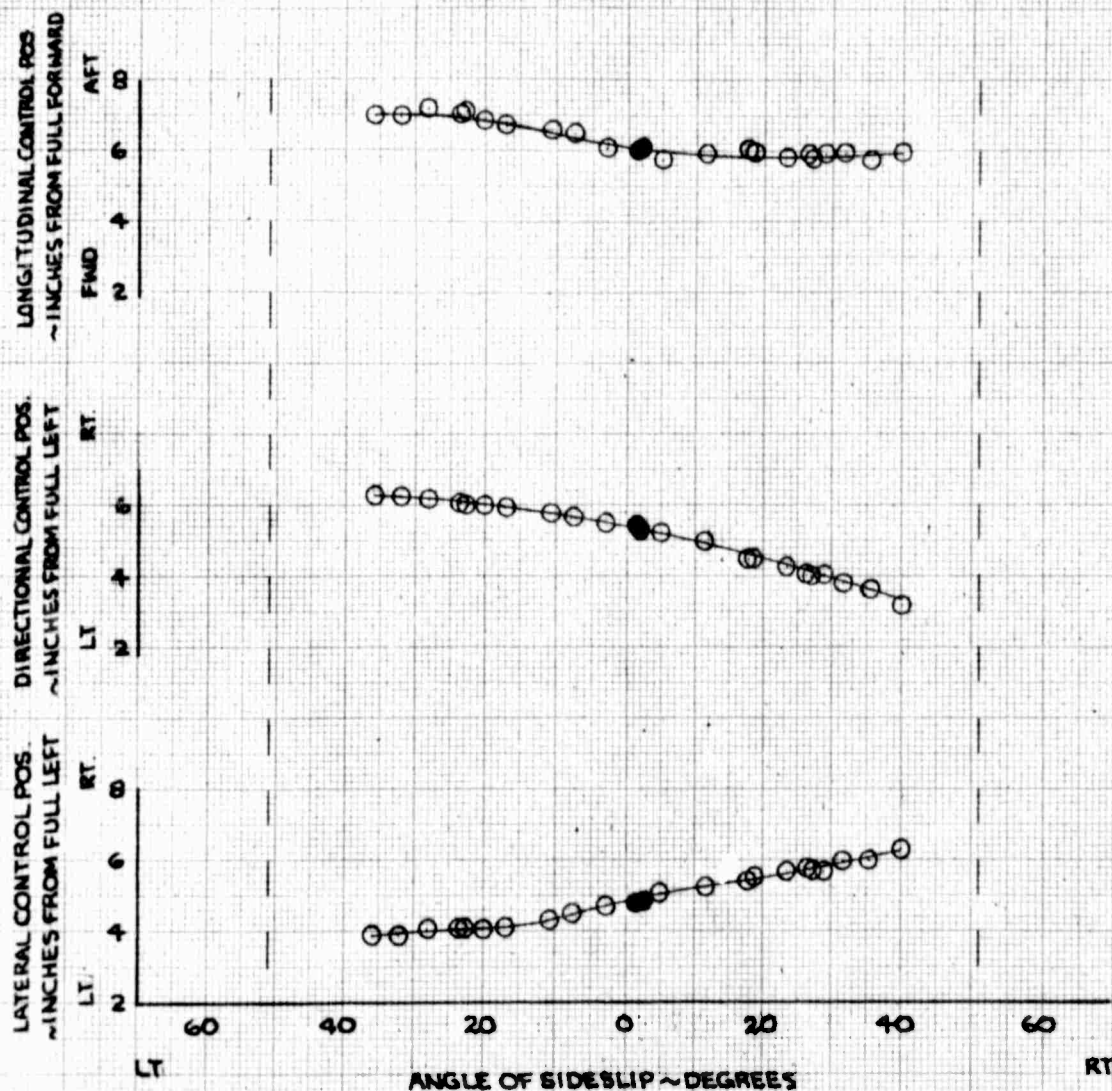
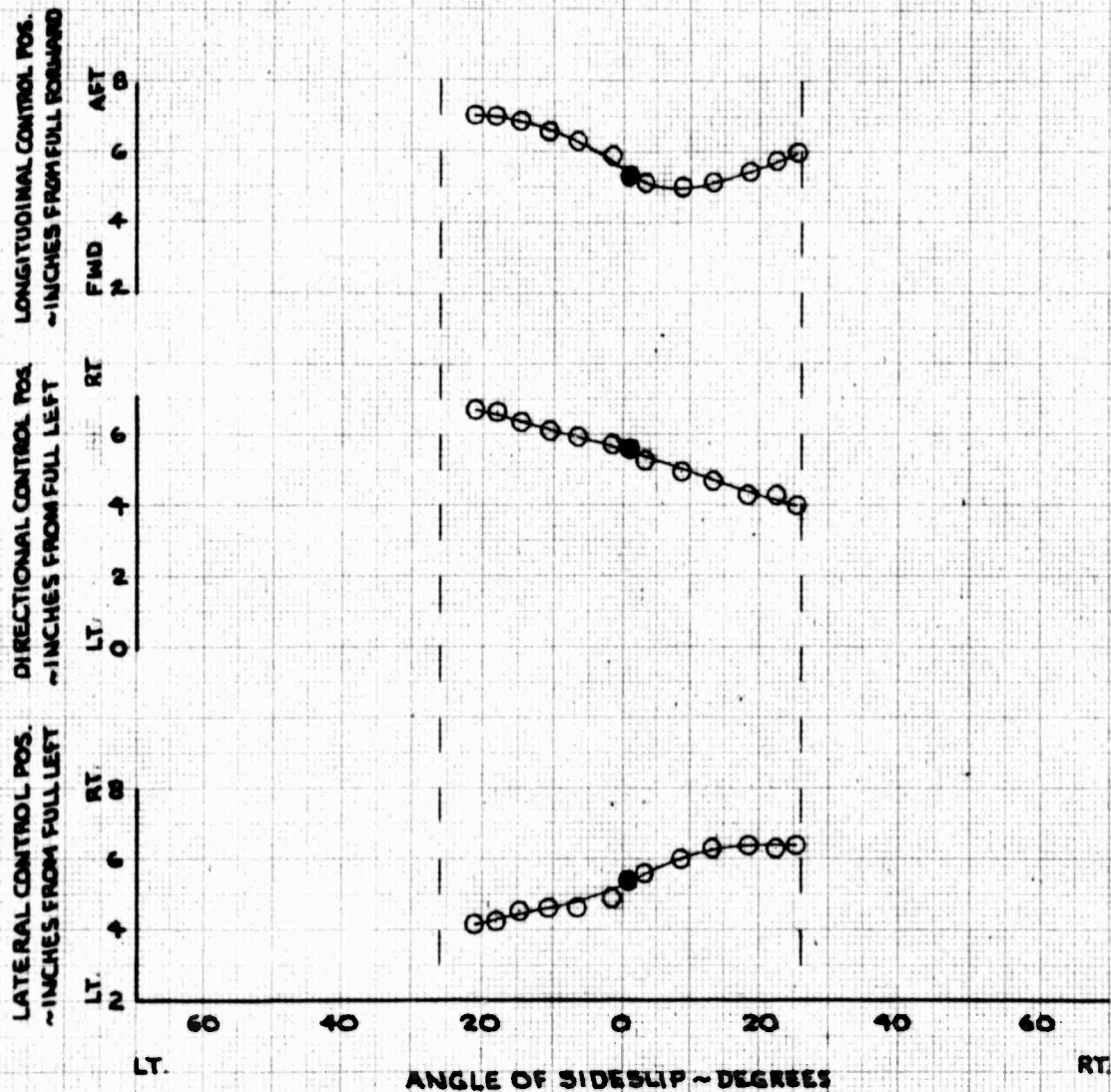


FIGURE 25 **STATIC LATERAL - DIRECTIONAL STABILITY** 369C 9465-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG. CG ~IN.	ROTOR SPEED ~RPM	AVG CT	AVG TRIM AIRSPEED COND ~KNOTS	FLT COND
2400	3090	23.0	104.1 (AFT)	510	0.008120	85	LEVEL

- NOTES:
1. COLLECTIVE CONTROL POSITION HELD FIXED DURING TEST
 2. SHADED SYMBOLS DENOTE TRIM POINT
 3. TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES
 4. BROKEN LINES DENOTE LEVEL FLIGHT SIDE SLIP LIMITS

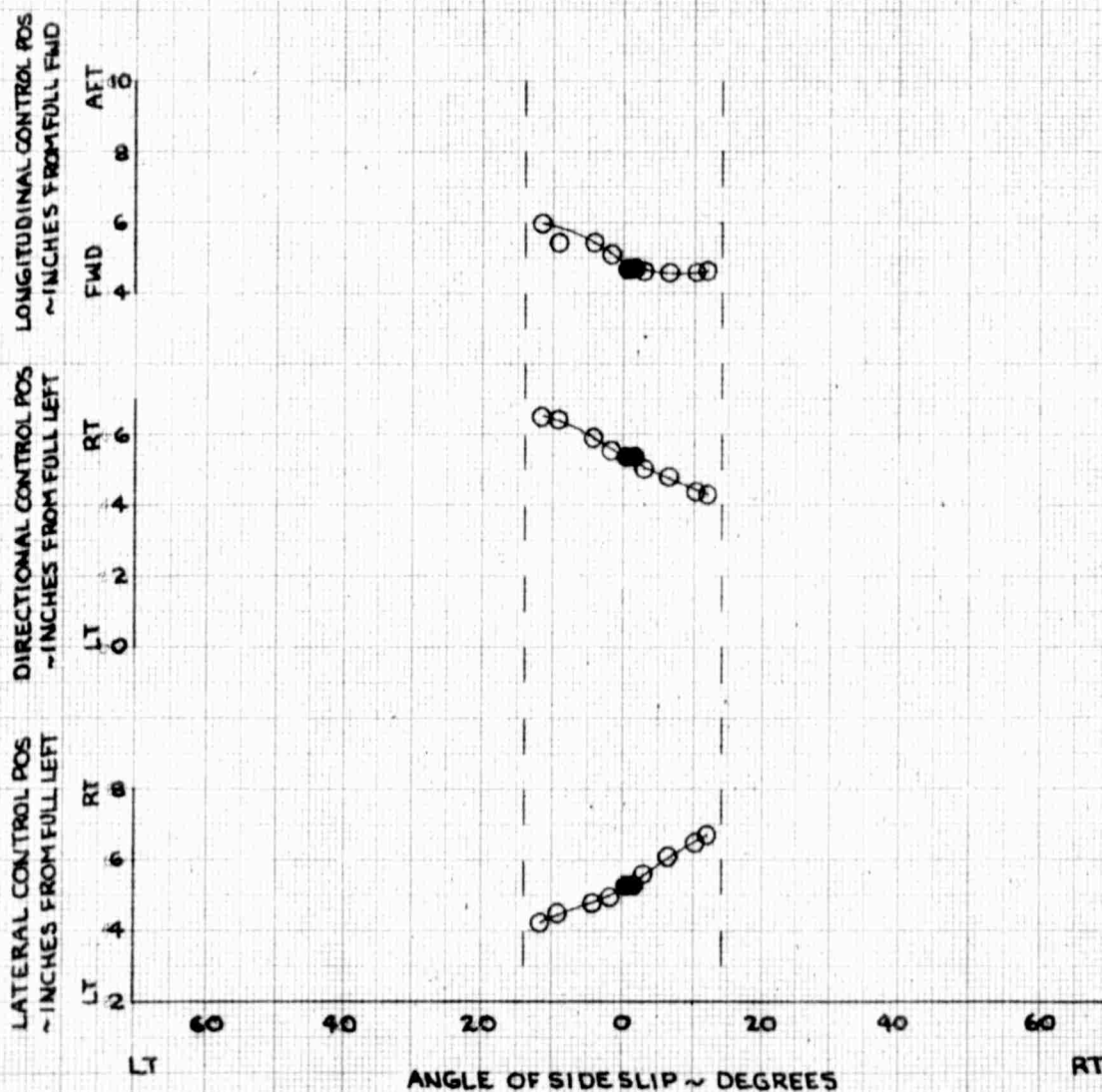


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FIGURE 26
STATIC LATERAL-DIRECTIONAL STABILITY
369C 9/465-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG CG ~IN	ROTOR SPEED ~RPM	AVG Ct	AVG TRIM AIRSPEED ~KIAS	FLT COND
2370	3080	25.5	104.1(AFT)	510	0.005099	107	LEVEL

- NOTES: 1. COLLECTIVE CONTROL POSITION HELD
FIXED DURING TEST
2. SHADED SYMBOLS DENOTE TRIM POINT
3. TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES
4. BROKEN LINES DENOTE LEVEL FLIGHT
SIDE SLIP LIMITS



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FIGURE 27
STATIC LATERAL-DIRECTIONAL STABILITY
369C 65-12951

AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG CG ~IN. (AFT)	ROTOR SPEED ~RPM	AVG CY	AVG TRIM AIRSPEED ~KIAS	FLT COND
2420	3110	26.0	104.1	810	0.005156	157	LEVEL

- NOTES: 1. COLLECTIVE CONTROL POSITION HELD
FIXED DURING TEST
2. SHADED SYMBOLS DENOTE TRIM POINT
3. TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES
DIRECTIONAL = 7.60 INCHES
4. BROKEN LINES DENOTE LEVEL FLIGHT
SIDE SLIP LIMITS

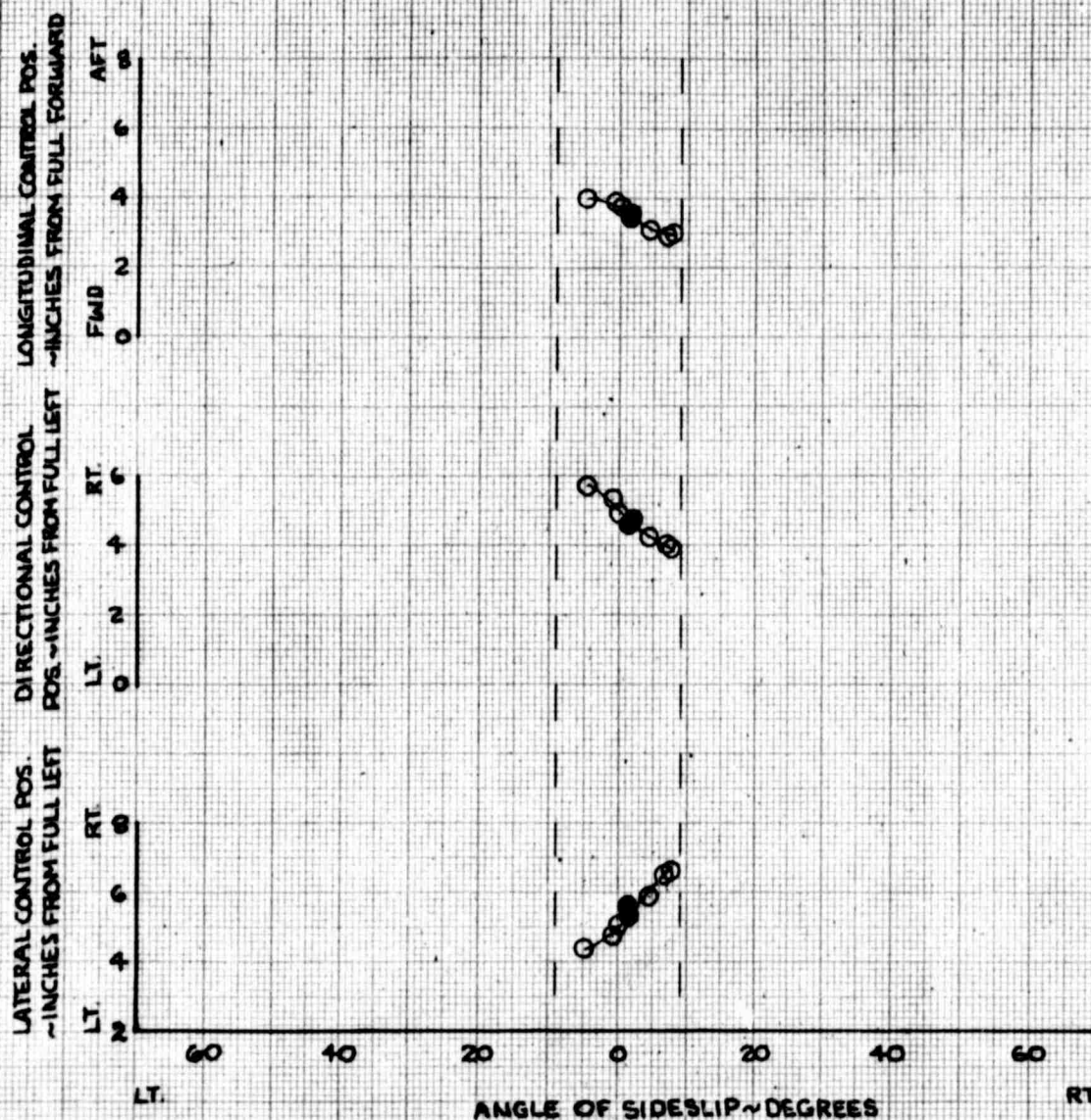


FIGURE 28 **STATIC LATERAL-DIRECTIONAL STABILITY** **369C** **5/65-12951**

AVG DENSITY	AVG GRWT	AVG OAT	AVG LONG. CG	ROTOR SPEED	AVG C_T	AVG TRIM AIRSPEED	FLT COND
~FT	~LB	~°C	~IN	~RPM		~KCAS	
2400	2440	19.0	103.9(AFT)	510	0.004043	105	LEVEL

- NOTES:**
1. COLLECTIVE CONTROL POSITION HELD FIXED DURING TEST
 2. SHADED SYMBOLS DENOTE TRIM POINT
 3. TOTAL CONTROL DISPLACEMENT
 LONGITUDINAL = 12.55 INCHES
 LATERAL = 11.55 INCHES
 DIRECTIONAL = 7.60 INCHES
 4. BROKEN LINES DENOTE LEVEL FLIGHT SIDESLIP LIMITS

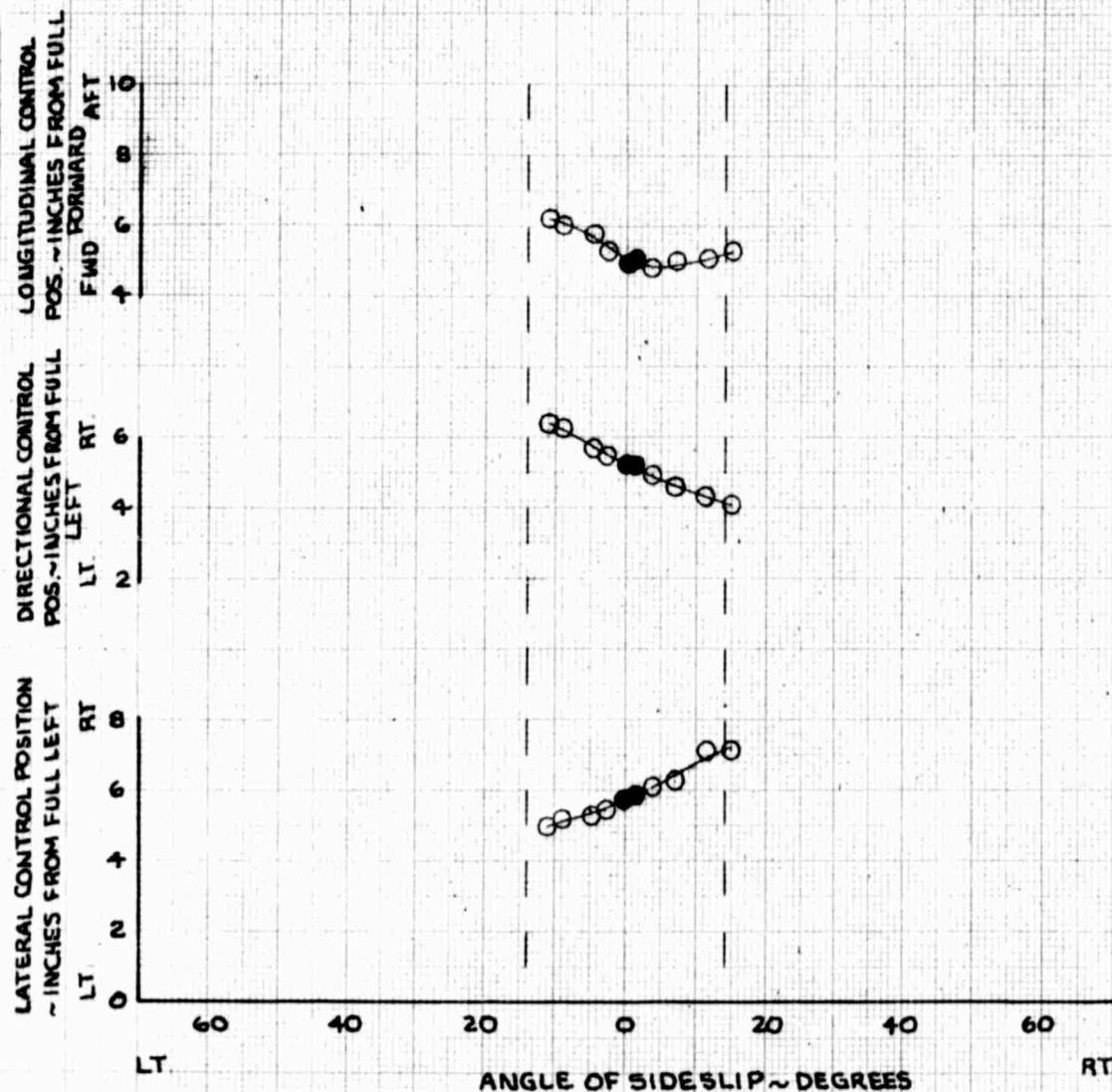


FIGURE 29
AIRCRAFT RESPONSE FOLLOWING AN AFT LONGITUDINAL PULSE

DENSITY	369 C	AVG LONG.	369 C	TRIM	FLT
ALTITUDE - FT	2490	CG - IN.	104.1 (AFT)	AIR SPEED - KCAS	COND
		CGMT - LB	3070	1370	LEVEL
		QAT - °C	30.0		
		ROTOR			
		SPEED - RPM	510		
		CT	0.005101		

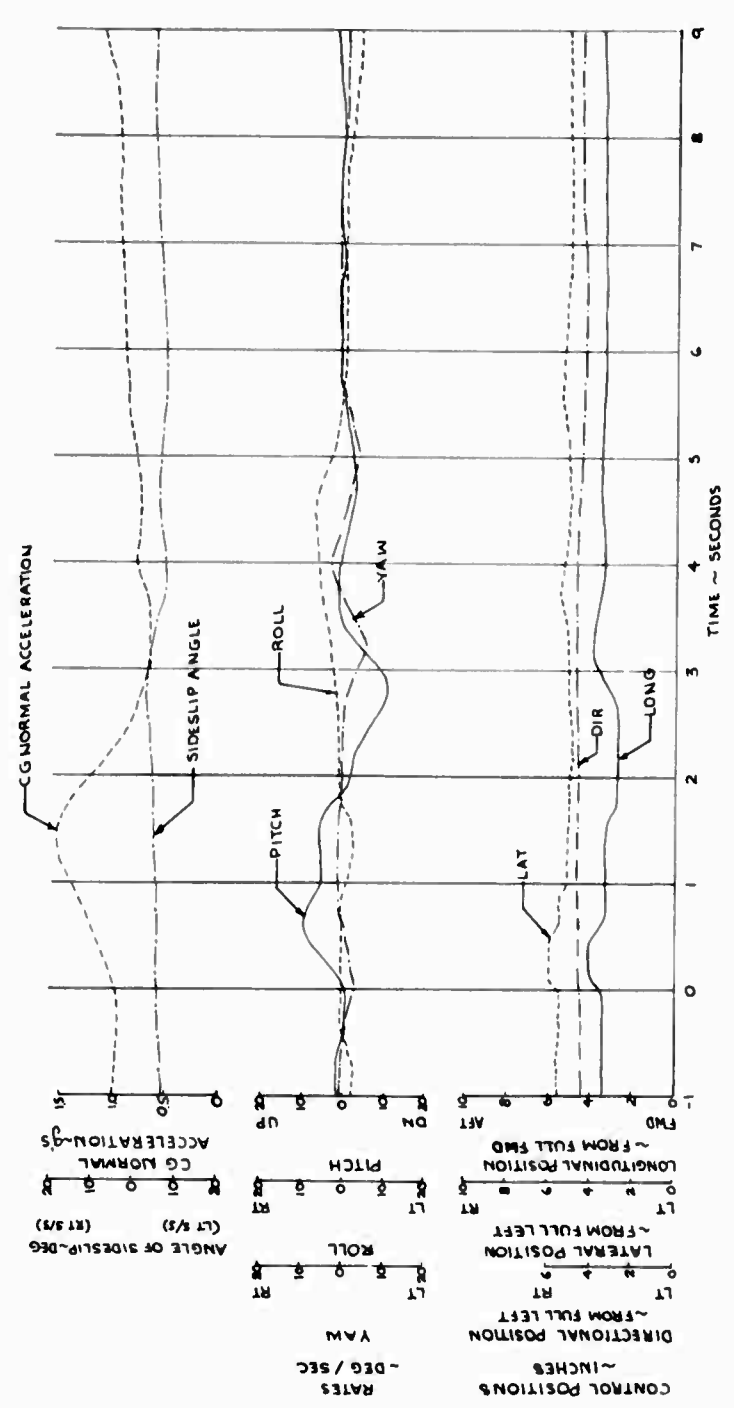


FIGURE 30
AIRCRAFT RESPONSE FOLLOWING A RIGHT LATERAL PULSE
369C 5/65-12951

DENSITY	AVG	AVG LONG	ROTOR	TRIM	FLT
ALTITUDE~FT	GRWT~LB	C G ~ IN	SPEED~RPM	AIR SPEED~KCAS	COND
2490	3070	104.1 (AFT)	510	137 0	LEVEL

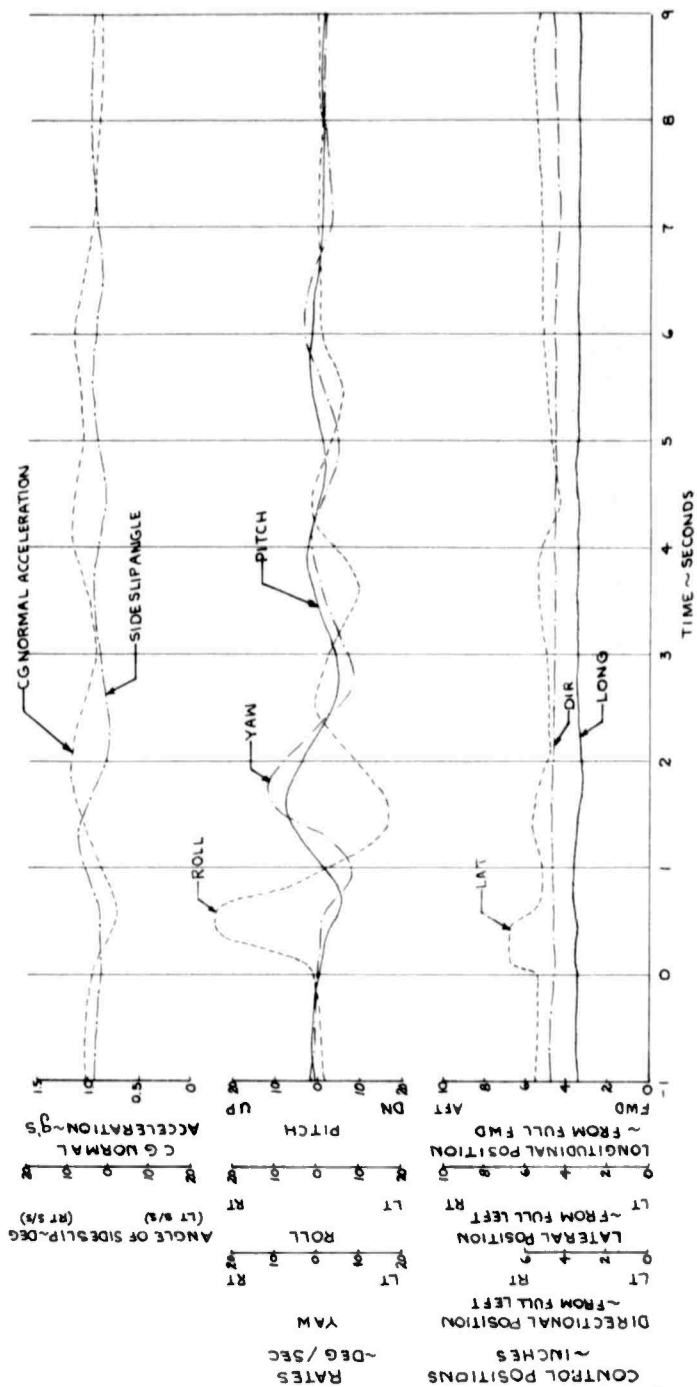


FIGURE 31
AIRCRAFT RESPONSE FOLLOWING A RIGHT DIRECTIONAL PULSE.

DENSITY ALTITUDE ~ FT	3690	AVG GRWT ~ LB	3060	OAT ~ °C	24.0	AVG LONG CG ~ IN	104.1 (AFT)	ROTOR SPEED ~ RPM	510	CT	0.005084	TRIM AIRSPEED ~ KCAS	1370	FLT CCND LEVEL
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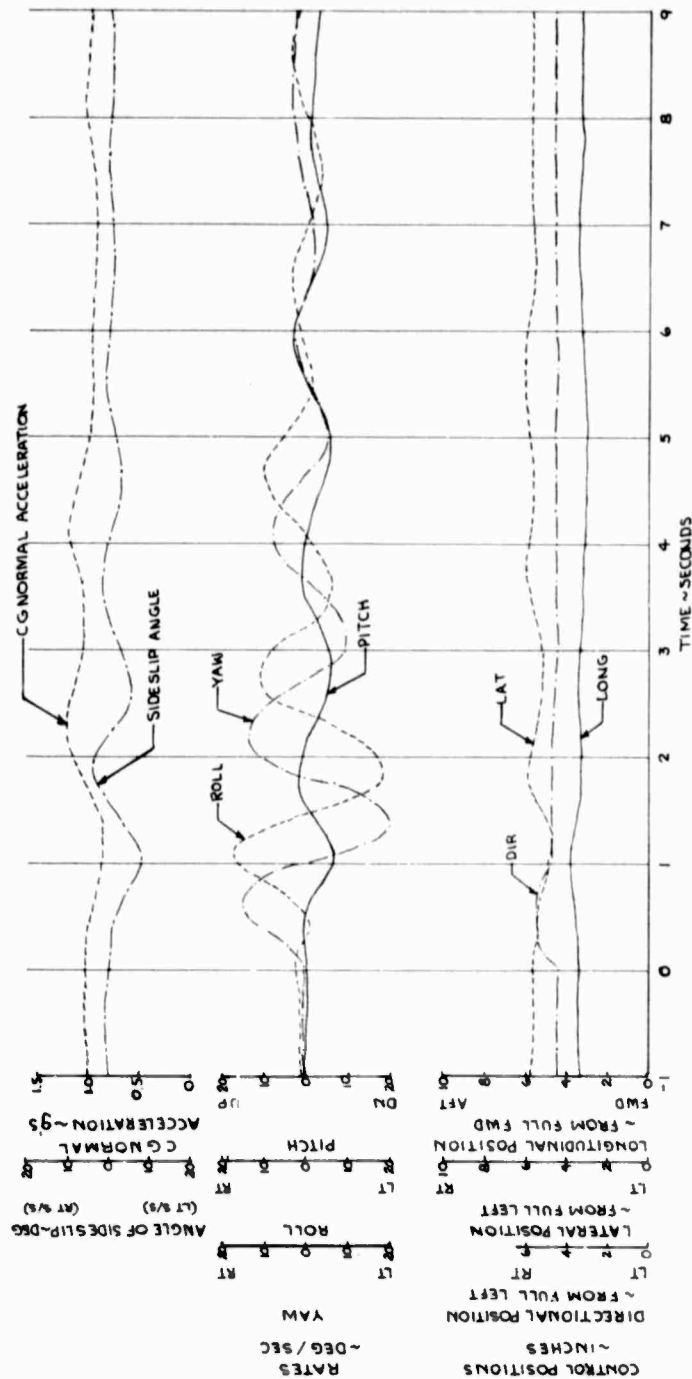


FIGURE 32
LONGITUDINAL CONTROLLABILITY
369C 5465-12951

SYMBOL	AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG. CG ~IN.	ROTOR SPEED ~RPM	AVG CT	AVG TRIM AIRSPEED ~KIAS	FLT COND
○	2400	2360	19.0	104.0 (AFT)	510	0.003911	105	LEVEL
□	2300	2440	28.5	104.1 (AFT)	510	0.004440	105	LEVEL

NOTE: TOTAL LONGITUDINAL CONTROL TRAVEL = 12.55 INCHES

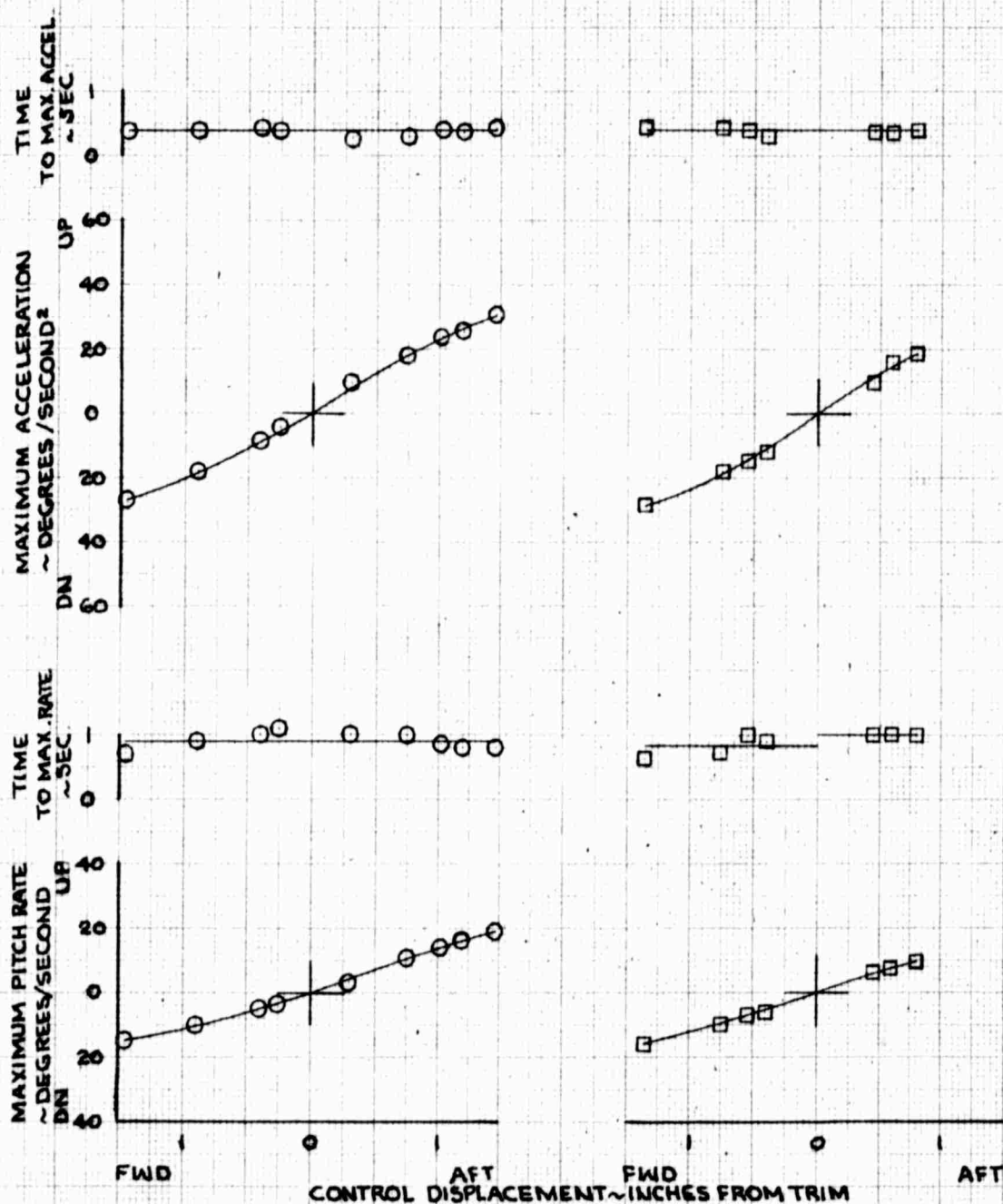


FIGURE 33
LONGITUDINAL CONTROLLABILITY
369 C 3465-12951

SYMBOL	AVG DENSITY ALTITUDE ~ FT	AVG GRWT ~ LB	AVG DAT ~ °C	AVG LONG. C.G. ~ IN	ROTOR SPEED ~ RPM	AVG CT	AVG TRIM AIRSPEED ~ KCAS	FLY COND
○	1080	5100	22.0	104.1(AFT)	510	0.004750	HOVER	LEVEL
□	2450	3070	30.0	104.1(AFT)	510	0.005101	137	LEVEL

NOTE: TOTAL LONGITUDINAL CONTROL TRAVEL = 12.55 INCHES

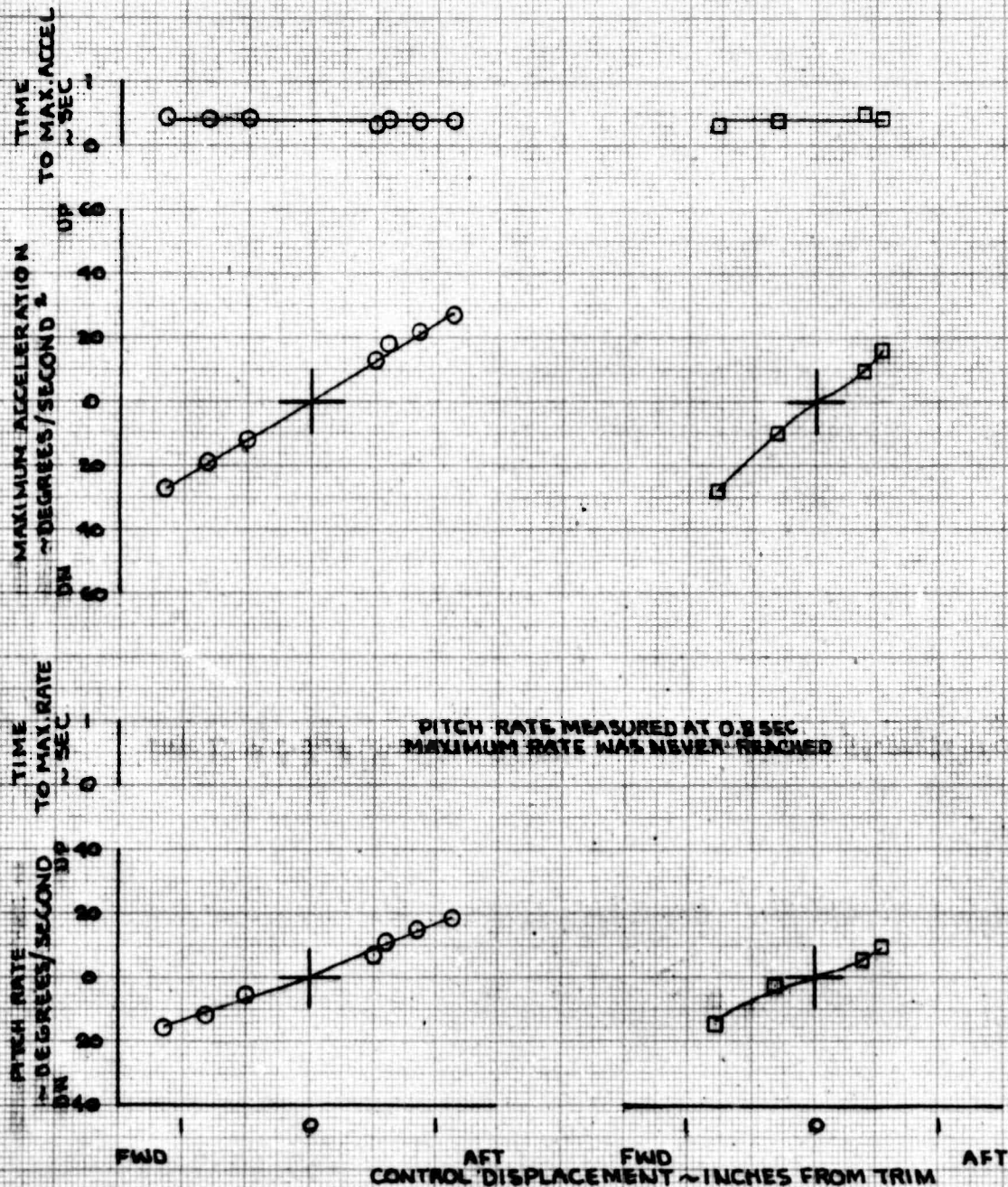


FIGURE 34
LATERAL CONTROLLABILITY
 369C 8/165-12951

SYMBOL	AVG DENSITY ALTITUDE ~ FT	AVG GRWT ~ LB	AVG OAT ~ °C	AVG LONG. CG ~ IN.	ROTOR SPEED ~ RPM	AVG CT	AVG TRIM AIRSPEED ~ KCAS	FLT COND
○	2400	2360	19.0	104.0 (AFT)	510	0.003911	105	LEVEL
□	2300	2490	28.5	104.1 (AFT)	510	0.004240	105	LEVEL

NOTE : TOTAL LATERAL CONTROL TRAVEL = 11.55 INCHES

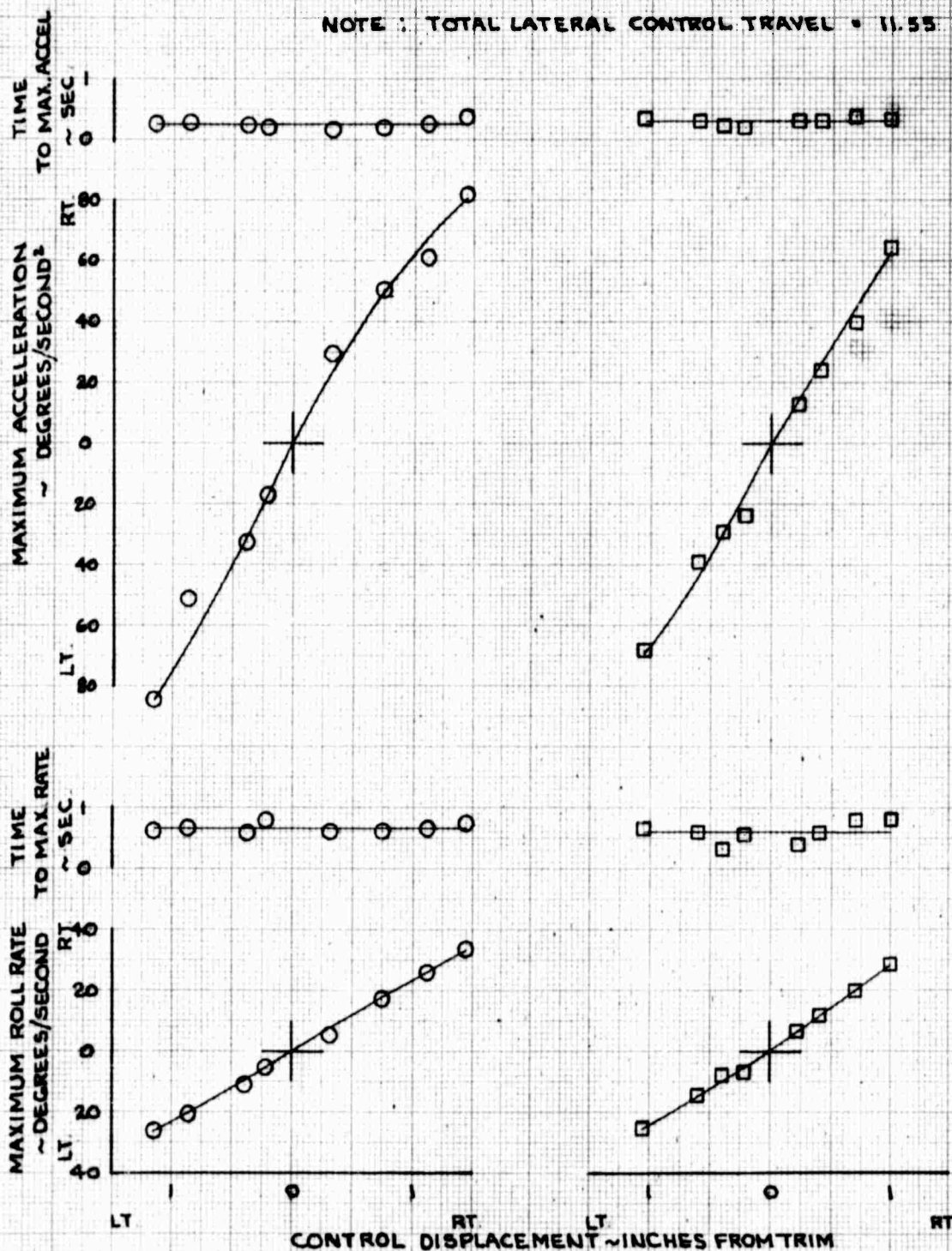


FIGURE 35
LATERAL CONTROLLABILITY
369C **3463-12951**

SYMBOL	AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG. CG ~IN.	ROTOR SPEED ~RPM	AVG CT	AVG TRIM AIRSPEED ~KIAS	FLT COND
○	1080	3060	22.0	104.1 (AFT)	510	0.004876	HOVER	LEVEL
□	2490	3070	30.0	104.1 (AFT)	510	0.005101	137	LEVEL

NOTE: TOTAL LATERAL CONTROL TRAVEL = 11.55 INCHES

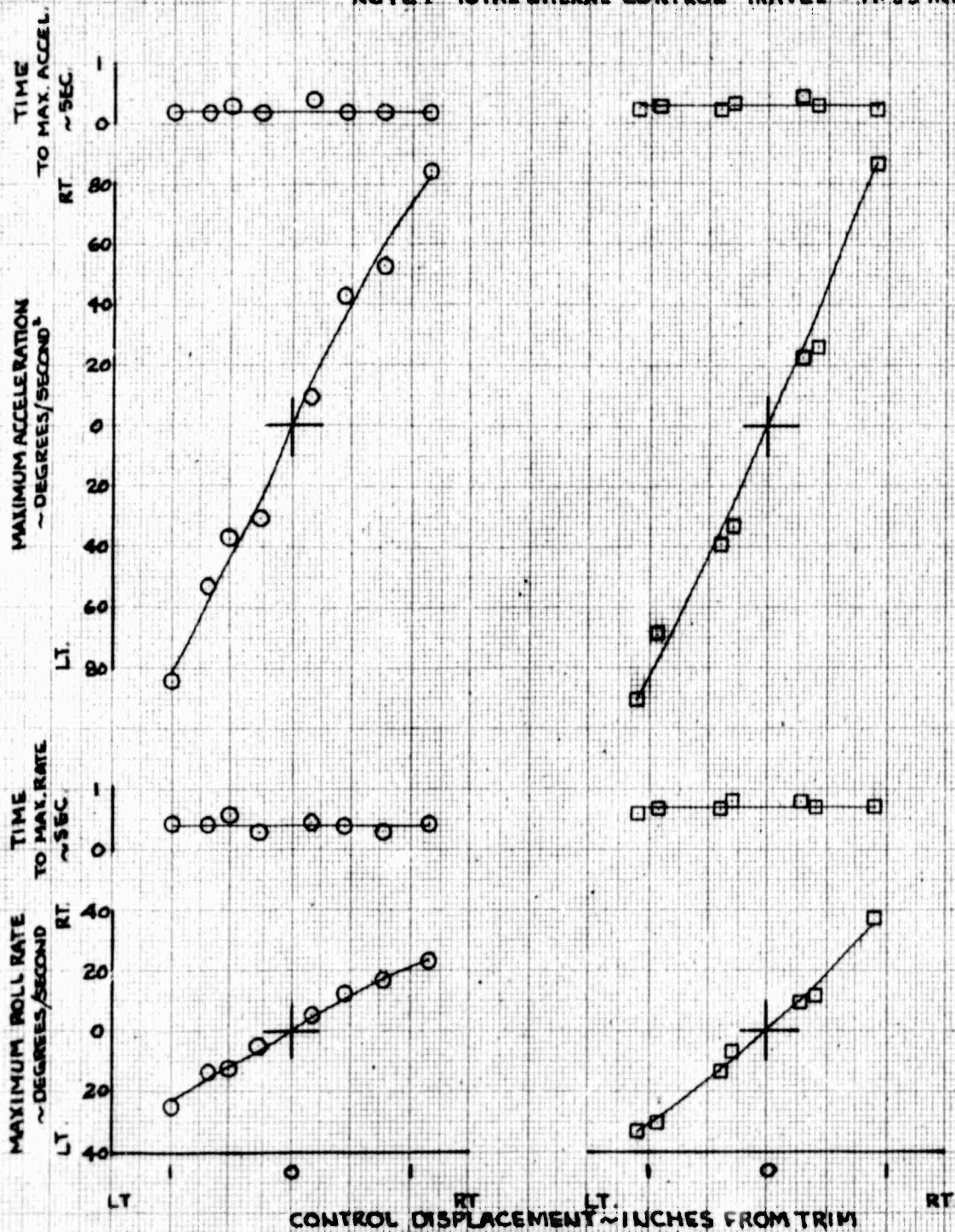


FIGURE 36
DIRECTIONAL CONTROLLABILITY
369C **9465-12951**

SYMBOL	AVG DENSITY ALTITUDE ~ FT	AVG GRWT ~ LB	AVG OAT ~ °C	AVG LONG CG ~ IN.	ROTOR SPEED ~ RPM	AVG C _T	AVG TRIM AIRSPEED ~ KCAS	FLT COND
○	2400	2360	19.0	104.0(AFT)	510	0.003911	105	LEVEL
□	2300	2490	28.5	104.1(AFT)	510	0.004440	105	LEVEL

NOTE: TOTAL DIRECTIONAL CONTROL TRAVEL: 7.60 INCHES

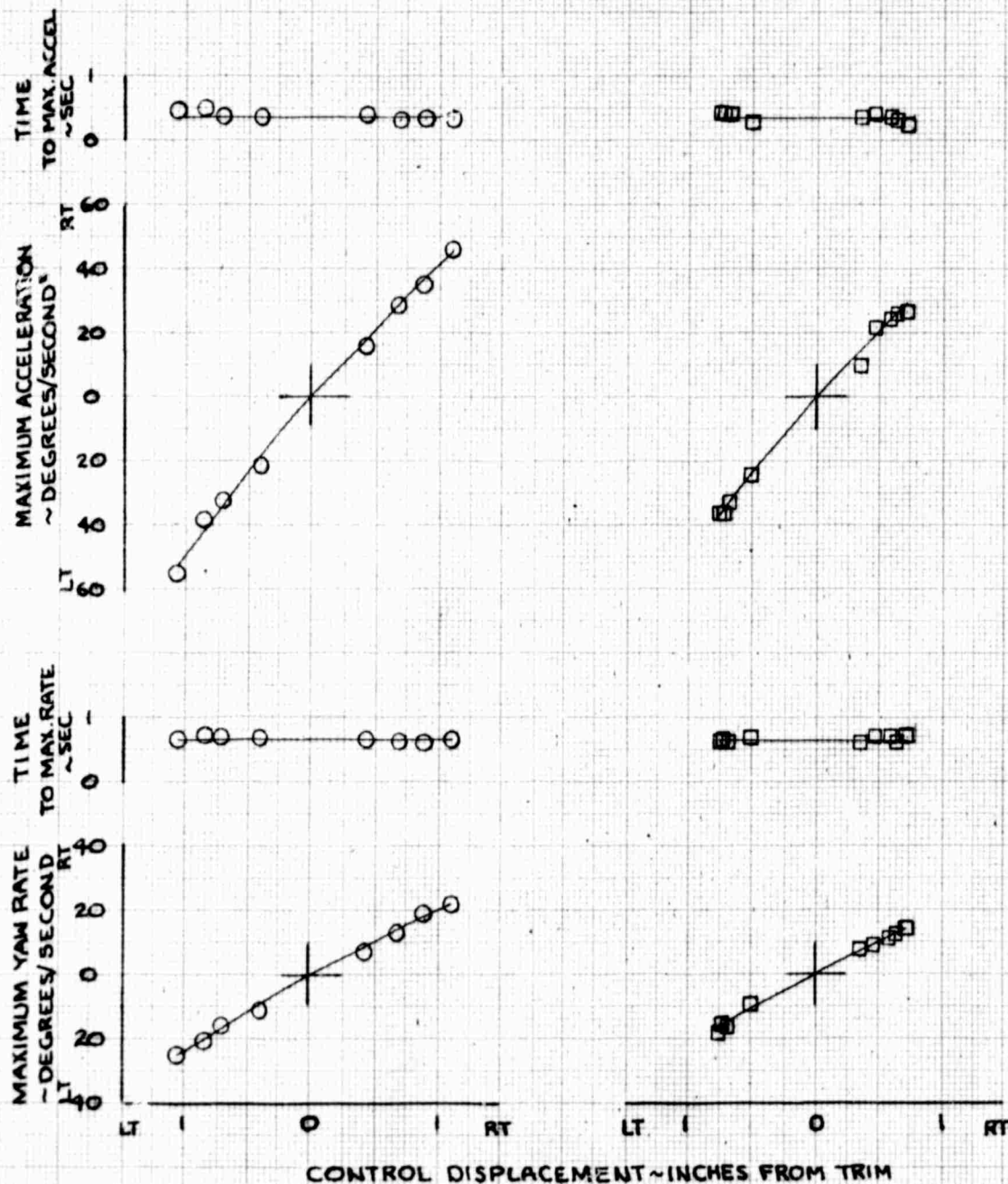


FIGURE 37
DIRECTIONAL CONTROLLABILITY
369C 5463-12951

SYMBOL	AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG. CG ~IN.	ROTOR SPEED ~RPM	AVG CT	AVG TRIM AIRSPEED ~KIAS	FLT COND
○	500	3170	19.0	103.9(AFT)	510	0.004946	HOVER	LEVEL
□	2490	3060	24.0	104.1(AFT)	510	0.005084	137	LEVEL

NOTE: TOTAL DIRECTIONAL CONTROL TRAVEL = 7.60 INCHES

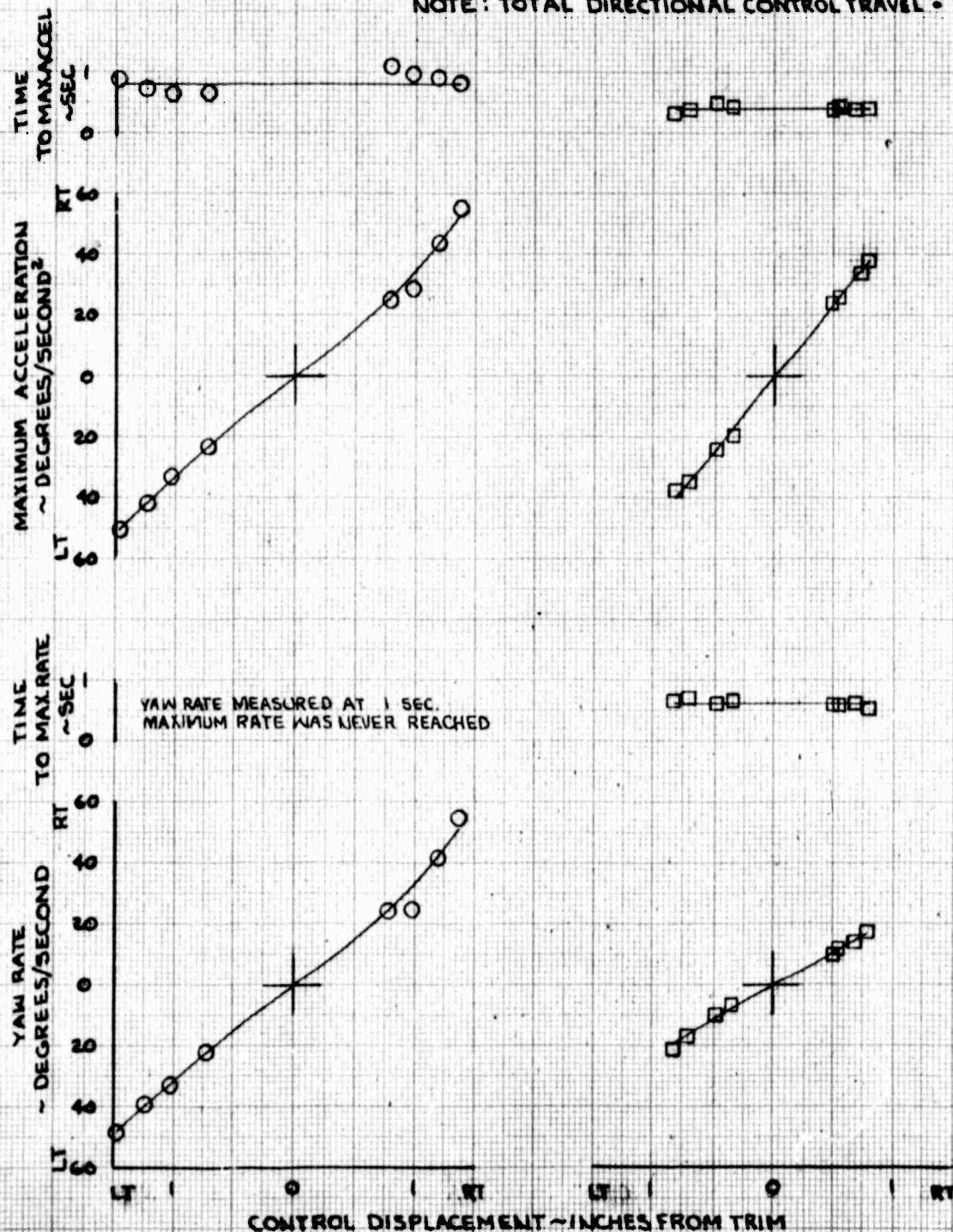


FIGURE 38
MANEUVERING STABILITY
369C ANG-12951

SYMBOL	AVG DENSITY ALTITUDE ~FT	AVG GRWT ~LB	AVG OAT ~°C	AVG LONG CG ~IN	ROTOR SPEED ~RPM	AVG CY	AVG TRIM AIRSPEED ~KCAS
□	1800	3020	20.0	104.1 (AFT)	510	0.004916	106
○	1900	3090	20.5	104.1 (AFT)	510	0.005045	136

NOTES: 1. OPEN SYMBOLS DENOTE LEFT WIND-UP TURNS
2. SHADED SYMBOLS DENOTE RIGHT WIND-UP TURNS
3. TOTAL CONTROL DISPLACEMENT
LONGITUDINAL = 12.55 INCHES
LATERAL = 11.55 INCHES

LATERAL CONTROL POSITION
~INCHES FROM FULL LEFT

RT
0
2
4
6
8
LT

LONGITUDINAL CONTROL POSITION
~INCHES FROM FULL FORWARD

AFT
0
2
4
6
8
FWD

0.8 1.0 1.2 1.4 1.6 1.8 2.0

C.G. NORMAL ACCELERATION ~G'S

FIGURE 39
AIRCRAFT RESPONSE FOLLOWING A SIMULATED ENGINE FAILURE

INITIAL DENSITY ALTITUDE ~ FT	AVG GRWT ~ LB	INITIAL OAT ~ °C	AVG LONG. C.G. ~ IN.	INITIAL ROTOR SPEED ~ RPM	INITIAL CT	TRIM AIRSPEED ~ KIAS	INITIAL FLT COND LEVEL
3260	3100	22.0	104.2 (AFT)	510	0.005270	124.0	

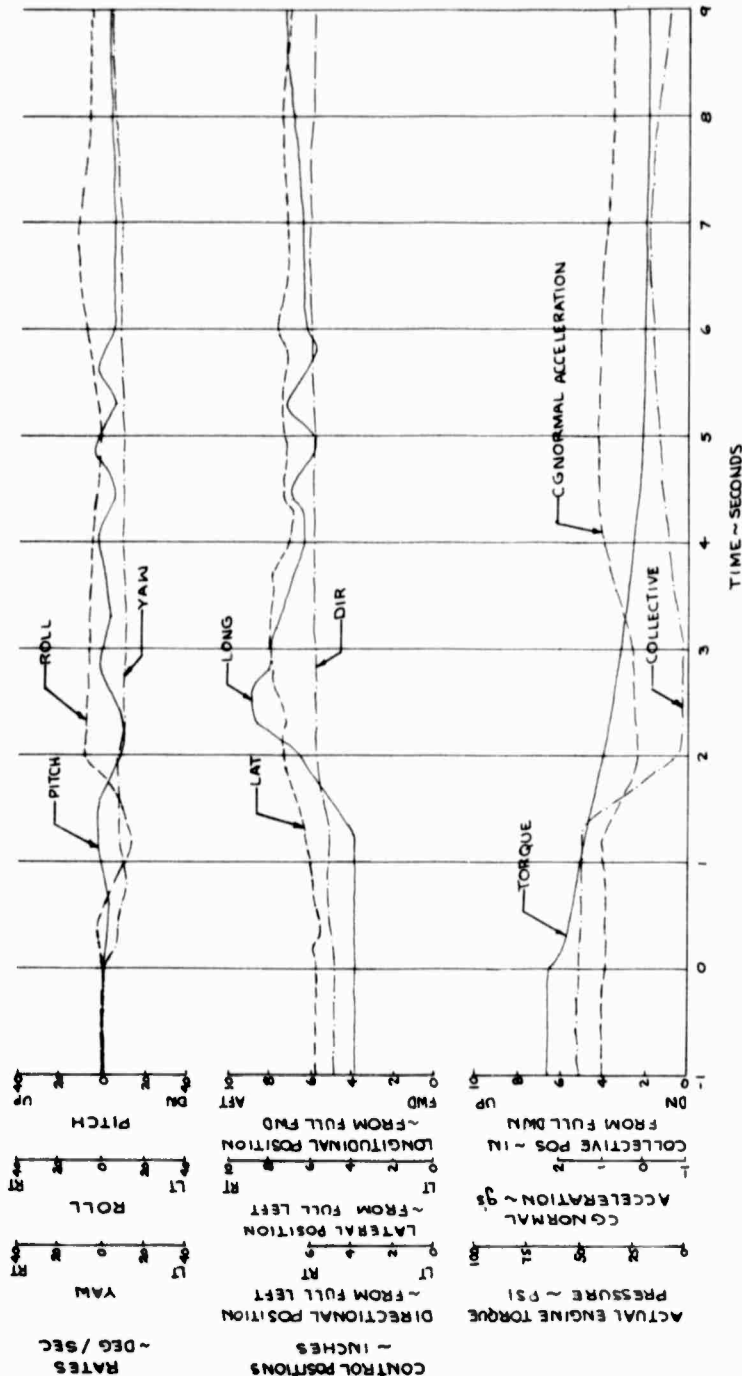
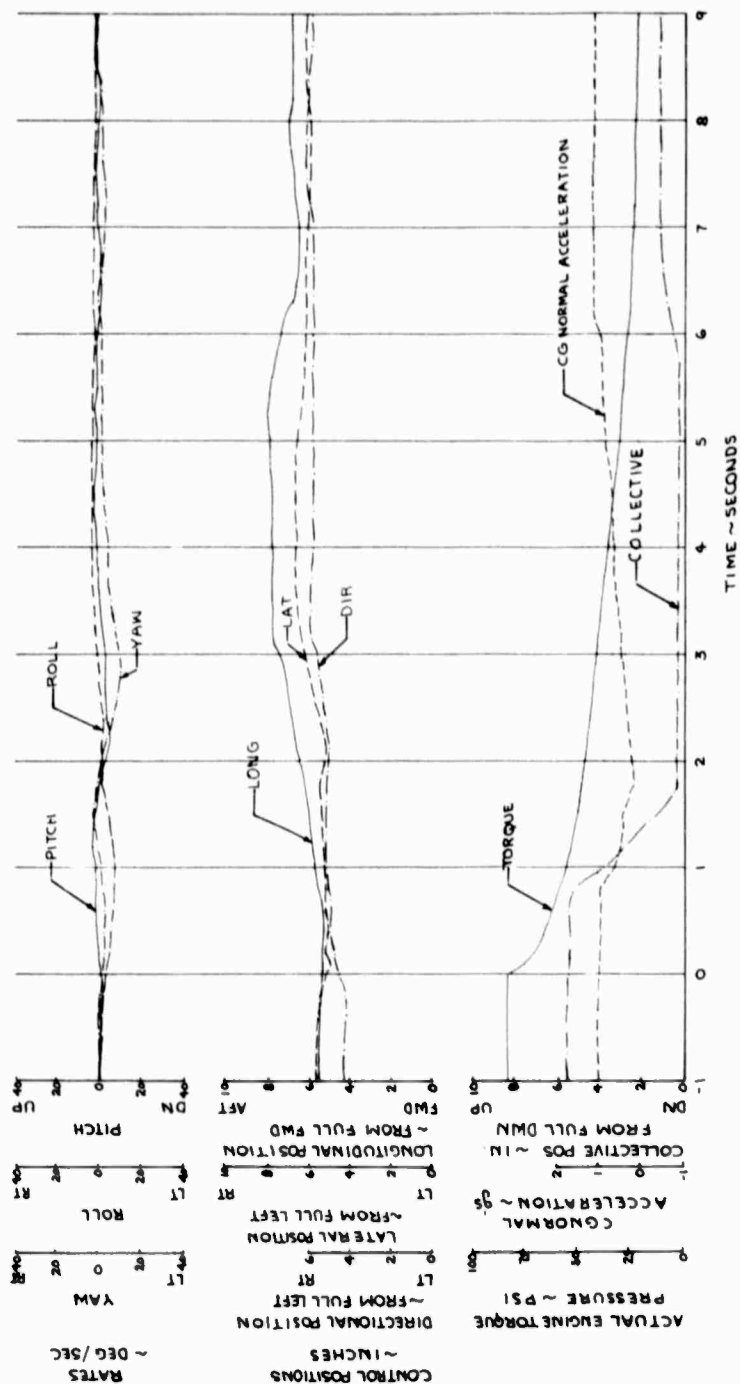


FIGURE 40
AIRCRAFT RESPONSE FOLLOWING A SIMULATED ENGINE FAILURE
369C

INITIAL DENSITY ALTITUDE ~ FT	AVG GRWT-LB	INITIAL OAT-°C	AVG LONG. CG-IN	INITIAL ROTOR SPEED-RPM	INITIAL CG	TRIM AIRSPEED-KCAS	INITIAL FLT COND
2810	3050	180	1040(AFT)	510	000816	610	MAX POWER CLIMB



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FIGURE 41

AIRSPEED CALIBRATION

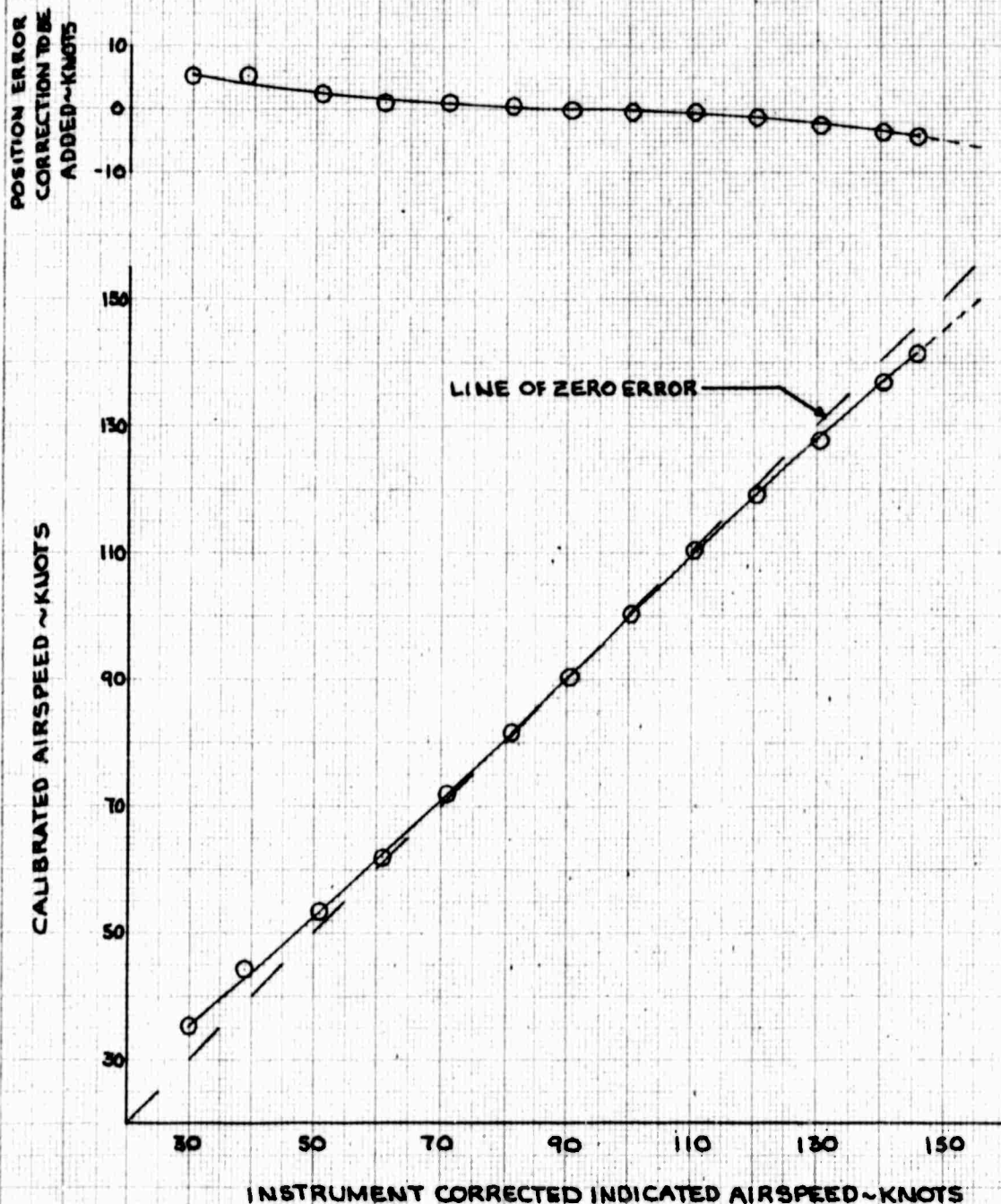
869C

1/165-12951

BOOM SYSTEM

AVG DENSITY ALTITUDE ~FT 800	AVG GRWT ~LB 3080	AVG OAT ~°C 20.0	AVG LONG. CG ~IN 104.0(AFT)	ROTOR SPEED ~RPM 510	FLT COND LEVEL
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NOTE: DATA COLLECTED USING GROUND SPEED
COURSE METHOD



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DOCUMENT CONTROL DATA - R & D

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5. AUTHOR(S) (First name, middle initial, last name) GARY L. SKINNER, Project Engineer RANDY D. McCLELLAN, Engineer ARLIN DEEL, LTC, CE, US Army, Project Officer/Pilot			
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11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY US ARMY AVIATION SYSTEMS COMMAND ATTN: AMSAV-EF PO BOX 209, ST. LOUIS, MISSOURI 63166	
13. ABSTRACT The Army Preliminary Evaluation (APE) of the Hughes Tool Company - Aircraft Division (HTC-AD) prototype Model 369C (OH-6C) helicopter was conducted at the Hughes facility in Culver City, California. A total of 34.6 productive flight hours were accumulated during the period 26 August to 22 September 1971. Engineering flight tests were conducted to evaluate the performance, handling qualities, and contractor-proposed flight envelope and to provide data for future use in the evaluation of the HTC-AD New Initiatives - Aerial Scout Program proposal. The data indicate that, in comparison with the OH-6A, the Hughes Model 369C can hover out of ground effect on a 35°C day at 4000 feet with a 207-pound increase in payload. The Model 369C can achieve a maximum level flight airspeed of 141 knots calibrated airspeed (KCAS) with a 660-pound payload - an increase of 14 percent over the 124-KCAS never-exceed velocity of the OH-6A. One deficiency, inadequate longitudinal control during sideward and rearward flight at a forward center-of-gravity (cg) loading, and 12 shortcomings were observed in the handling qualities evaluation. In the OH-6A speed range, the static and dynamic stability and controllability of the Model 369C are generally unchanged. At the airspeeds that exceeded the envelope of the OH-6A, handling qualities were degraded, and 5 shortcomings were observed. These shortcomings were neutral maneuvering and static longitudinal stability, excessive longitudinal control response and sensitivity, excessive roll response following a simulated directional gust disturbance, and excessively rapid buildup of normal acceleration following a simulated longitudinal gust disturbance. If procurement of the helicopter is planned, the cited deficiency should be corrected prior to any airworthiness release for flight at a forward cg loading by operational pilots. The shortcomings should be corrected prior to production. Additional testing should be conducted to determine a safe operational cg envelope, to develop a height-velocity curve, and to evaluate the effects of altitude, weight, and cg variations.			

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Army Preliminary Evaluation HTC-AD Model 369C (OH-6C) helicopter Evaluate performance, handling qualities, and contractor-proposed flight envelope Provide data Data indicate One deficiency 12 shortcomings Handling qualities evaluation Deficiency should be corrected prior to release Shortcomings should be corrected prior to production Additional testing should be conducted						

SUPPLEMENTARY

INFORMATION



DEPARTMENT OF THE ARMY
U. S. ARMY AVIATION SYSTEMS TEST ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

SAVTE-T

SUBJECT: Report, US Army Aviation Systems Test Activity, USAASTA
Project No. 71-34, *Army Preliminary Evaluation, Prototype*
Hughes, Model 369C (OH-6C) Helicopter, February 1972

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1. Table 1, Hovering Capability Comparison, as shown on page 5 of the subject report is herewith changed for correction of typed errors. The corrected table is included as Inclosure 1.
2. The last sentence of paragraph number 31 and 13 of the subject report is herewith changed to read, "The test results are presented in figures 24 through 28, appendix G."
3. Included within appendix F, Test Instrumentation, after page 40 of the subject report for clarification of instrumentation location should be a side-view of the 369C that was previously omitted. The diagram is included as Inclosure 2.
4. After the above changes have been posted, this letter will be filed with the subject report.

FOR THE COMMANDER:

GLEB D. KASHIN
Major, TC
Adjutant

- 2 Incl
1. Table 1, Hovering
Capability Comparison
 2. Diagram - 369C
Helicopter

HD-901268L

Table 1. Hovering Capability Comparison.

Pressure Altitude: 4000 feet
Outside Air Temperature: 35°C

Characteristic	Hughes Model 369C	OH-6A	Difference
Basic weight ¹ (lb)	1344	1146	198
Rotor speed ² (rpm)	510	483	27
Operating weight ³ (lb)	1950	1752	198
IGE ⁴ hover performance:			
Maximum hover weight (lb)	2850	2395	455
Payload (lb)	900	643	257
OGE hover performance:			
Maximum hover weight (lb)	2600	2195	405
Payload (lb)	650	443	207

¹Includes helicopter airframe and engine plus full hydraulic fluid and trapped fuel.

²Power turbine speed (N₂) equals 103 percent.

³Includes basic weight plus engine oil, full fuel, and a 200-pound pilot.

⁴Four-foot skid height.

